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Report DAAK40-76-C-1256-A001

DESIGN OF A FACILITY TO IMPLEMENT A LOW COST PROCESS FOR PRODUCTION OF NHC.

Callery Chemical Company
Division of Mine Safety Appliances Company
Callery, Pennsylvania 16024

327p.

15 May 1979

Final Technical Report.
26 Nov 76 - 31 Oct 77.

Prepared for
HEADQUARTERS
U. S. ARMY MISSILE RESEARCH AND DEVELOPMENT COMMAND
REDSTONE ARSENAL, ALABAMA 35809

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REPORT DOCUMENTATION PAGE

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1. REPORT NUMBER
DAAK40-76-C-1256-A001

2. GOVT ACCESSION NO.

3. RECIPIENT'S CATALOG NUMBER

4. TITLE (and Subtitle)
Design of a Facility to Implement a Lowcost Process for Production of NHC.

5. TYPE OF REPORT & PERIOD COVERED
Final Technical Report
16 November 1976 - 31 Oct. 1977

6. PERFORMING ORG. REPORT NUMBER
CCC - ~~77-149~~ 79-66

7. AUTHOR(s)

8. CONTRACT OR GRANT NUMBER(s)

9. PERFORMING ORGANIZATION NAME AND ADDRESS
Callery Chemical Company
Division of Mine Safety Appliances Company

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS

11. CONTROLLING OFFICE NAME AND ADDRESS
Headquarters U. S. Army Missile R & D Command
Redstone Arsenal, AL - 35809

12. REPORT DATE

13. NUMBER OF PAGES

14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)

15. SECURITY CLASS. (of this report)

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)
This document has been approved for public release and sale; its distribution is unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)
Engineering Design; Chemical Process; Production; Flow Diagrams.

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)
This report and its referenced documentation provide the detailed engineering design of a facility for the production of 30,000 lbs/yr of n-hexyl carborane (NHC). The design criteria and design basis incorporate bench scale and small scale production data and exerpience to provide a safe, low cost process for conversion of diborane to decaborane by a unique continuous pyrolysis process. Decaborane is subsequently converted to NHC by batch solution processing. Process description, process flow diagrams and engineering flow diagrams fully describe the production

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facility. Process hazards are discussed and process safety features described. Principal hazards are borane toxicity and fire hazard of flammable materials and solvents. Design implementation is outlined with identification of equipment and support facilities for process demonstration, demonstration and support of low rate production and ultimate expansion to full scale design capacity. Detailed engineering drawings, specifications, calculations and other design documents are listed. Listed documents are maintained for record and for retrieval and usage by interested parties.

SUMMARY

This report presents the detailed engineering design of a facility for production of NHC (n-hexyl carborane). This effort, funded by the U.S. Army Missile R&D Command under Contract DAAK40-76-C-1256, provides the engineering basis for implementation of a low cost process developed by Callery Chemical Company, partially under separate Contract DAAK40-75-C-1243.

The major objective of this project was the design of a modular carborane facility with a maximum production capacity of 30,000 lbs of NHC per year on a 300 stream day (SD) per year basis. Additional objectives were:

Design and identification of the minimum equipment to demonstrate the process at a rate of 4,000 lbs NHC/300 SD/yr;

Design and identification of additional equipment necessary to support low rate production of 9,000 lbs NHC/300 SD/yr; and

Design and identification of additional equipment to expand production of NHC to design capacity of 30,000 lbs/300 SD/yr.

This report and its appended documentation provide the necessary engineering details (drawings, specifications, etc) to allow construction of the NHC production facility. The facility will be located on a portion of the Callery/Mine Safety Appliances plant site near the borough of Callery in southwest Butler County, Pennsylvania. In brief, the facility consists of two principal process areas enclosed for weather protection and safety. Necessary support facilities for the process operation include a drum storage area, tank farm, utilities area, waste incineration system and change house for operating personnel.

Off-site facilities connected to the production facility include natural gas, potable and process water, fire

water, sanitary sewers and sewage treatment system, electricity, telephone and diborane supply. These off-site requirements are provided by appropriately metered connections to the existing facilities of the Callery/Mine Safety Appliances plant.

Major operations at the production facility include handling of incoming raw materials, production process operations, waste incineration and handling of outgoing product and solid waste. Major process operations take place in two operating areas -- The B10 Area and the NHC Area.

Process operations in these operating areas are best described by reference to Figure 1, NHC Facility Block Diagram. In the B10 Area, diborane (B2) is converted to decaborane (B10) by continuous vapor phase pyrolysis in parallel unit reactors. Each unit reactor (12 required for 30,000 lbs/yr design capacity) consists of three 4 in. ID pipe loops staged in series to provide efficient B2 conversion and B10 yield. Condensed B10 product is collected in product hoppers and transferred to a dissolver where B10 is dissolved in reaction solvents, filtered and pumped to the NHC Area. In the NHC Area, B10 is converted by sequential batch solution processing to give crude NHC. The crude NHC is then extracted with pentane, washed with aqueous solutions and purified by solvent stripping and vacuum distillation to give the final product.

All process wastes, both vapor and liquid, are converted to relatively innocuous combustion products by direct flaring or incineration. Figure 1 shows all process wastes going to an incineration system which employs high temperature oxidation to destroy combustible organics, vaporize process waste water and convert the waste boron content to solid oxides and borates. Incineration combustion products are direct water quenched and bag filtered to remove and collect particulates. Collected particulate matter (primarily sodium carbonates and borates) is packaged in drums for contract waste disposal. Sanitary wastes are piped to the existing Callery/MSA waste

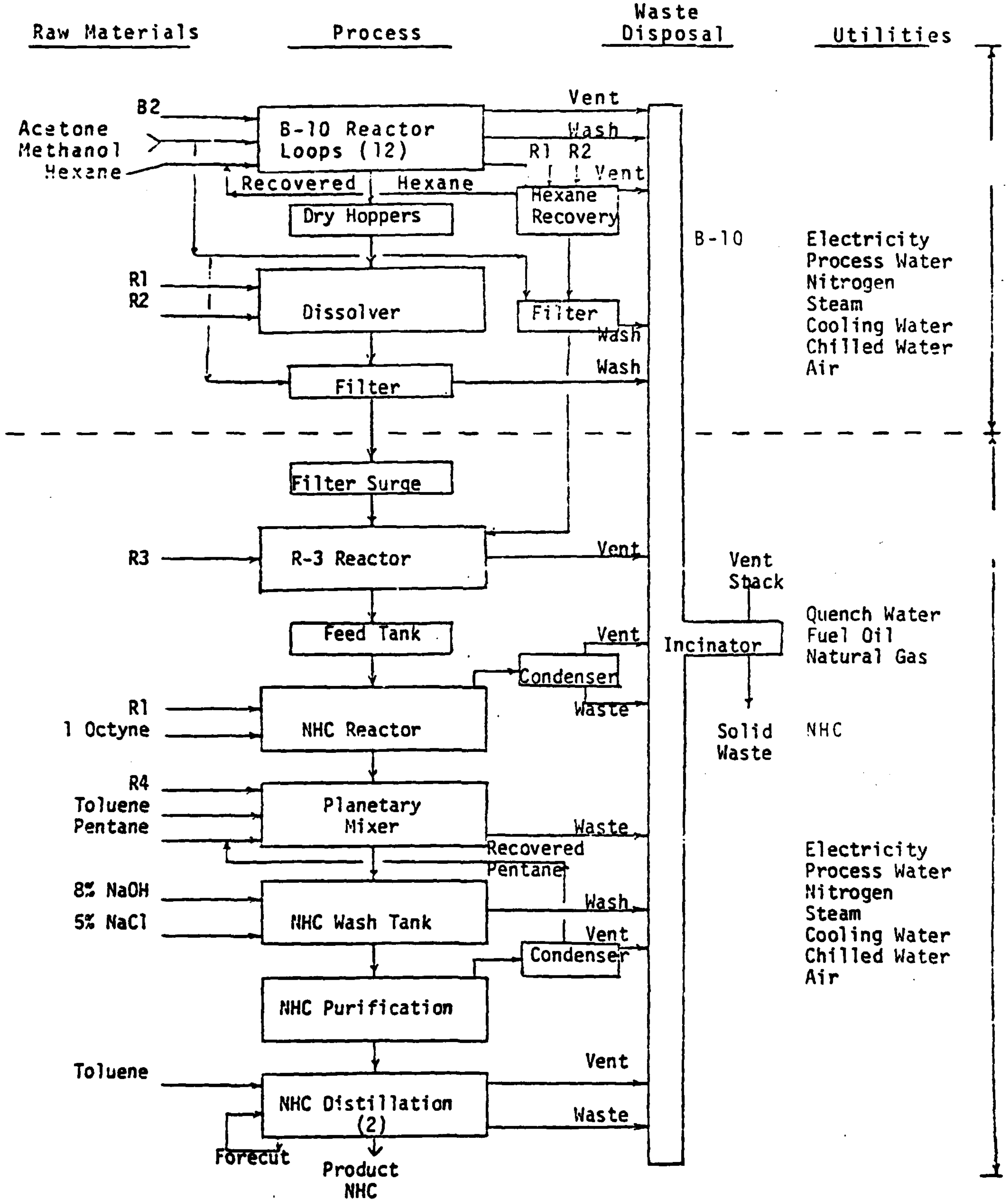

FIGURE 1 - NHC FACILITY BLOCK DIAGRAM

treatment facility. Assessment of environmental aspects of the NHC facility indicates that implementation of the design will not represent a major environmental action and will not require an Environmental Impact Statement.

The incineration system design is the only significant area of the facility that still requires further in-depth analysis. Tests conducted at the facilities of John Zink Company, Tulsa, Oklahoma verified the workability of the total waste incineration/particulate collection concept. The overall size and cost of the incineration system, however, has indicated a need for further tradeoff analysis that would provide the environmentally acceptable emission control at lower overall cost. Analysis of vapor vent streams indicates a potentially cost-effective modification which would involve scrubbing and direct flaring of selected vent streams, thus reducing significantly the vapor load to the incinerator. Scrubber liquor would be subsequently incinerated without significantly impacting incinerator size or performance.

In order to meet the project objectives and to allow design implementation by options for the process demonstration, low level production, and ultimate expansion to maximum design capacity, the design approach was as follows. The initial design was developed for the 30,000 lbs NHC/yr maximum design capacity. Using this full design equipment listing and related drawings, that equipment and support necessary for process demonstration and for low level production was identified. All other equipment items and support facilities were then deferred for installation under the option for expansion to 30,000 lbs/yr design capacity. This approach provides an operable system for meeting all of the project objectives.

During development of the facility design, a Design-to-Cost Program was implemented to meet the government's intent of developing a production facility to produce NHC at the lowest unit production cost and with minimum investment cost consistent

with technical limitations. The current in-depth analysis of incineration system trade-offs is an example of Design-to-Cost implementation. Detailed hazard analysis and design review by experienced operating personnel were employed to assure incorporation of necessary safety features to minimize hazards to plant personnel, equipment and the environment. A particular feature of the resultant facility design is the utilization throughout of low pressure process operations to minimize toxic exposure and explosion hazards. Principal hazards are those resulting from process operations using flammable vapors and liquids. Detailed review by insurance underwriters' engineering staff was made to assure a design meeting industry safety and fire protection criteria.

The body of this report and its listed documentation provides all documentation relating to plant design (with the exception of incinerator design details to be provided in a later submission) and specifically includes design criteria, data, calculation, drawings, layouts, equipment lists and specifications, process description, flowsheets and material balances, foundation investigation test results, off sites layouts and connection points, access roads and grading requirements. The design meets all applicable federal, state, local and industry standards, codes and schedules and is consistent with the requirements of the DOD Construction Criteria Manual(1).

Due to the voluminous documentation which makes up the total design package, this report contains only those principal documents which describe the NHC facility in broad terms (process flow diagrams, engineering flow diagrams, plot plan, etc.). The supplemental detailed design documentation listed in

(1) Construction Criteria Manual, Department of Defense, DOD 4720.1-M, October 1, 1972.

Appendix E will be maintained and made available for retrieval as follows:

1) Copies of drawings and originals of all other design documents and design calculations will be stored and maintained by Dravo Corporation, Chemical Plants Division, for a minimum of five years.

2) Original tracings and copies of all other design documentation will be stored and maintained by Callery Chemical Company, Division of Mine Safety Appliances, for the life of the NHC facility.

3) Record copies of all design documentation will be maintained at not more than two locations under the cognizance of the U. S. Army Missile R & D Command, Redstone Arsenal, Alabama.

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INTRODUCTION

This technical report presents the final facility design under Contract DAAK40-76-C-1256 (Sequence No. A001 of Contract DD Form 1423). The design effort was conducted by Callery Chemical Company and its principal engineering subcontractor Dravo Corporation during the period from November 12, 1976 through August 31, 1977.

The report and its appended documentation provide the engineering design for implementation of a low cost process for production of NHC (n-hexyl carborane) meeting the following project objectives quoted from Contract TR No. 6116:

> "Design a modular carborane facility with a maximum production capacity of 30,000 lbs NHC per year. The facility shall have a 15 year economic life and its annual production rate shall be based on an operating year of 300 stream days. The n-hexylcarborane (NHC) produced by this facility shall conform to the NHC specification Nr 1003, dated 14 Aug 74. The diborane feedstock shall be a minimum of 96 weight % pure diborane in the liquid phase and shall contain no more than a maximum of 2% noncondensables."

> "Design and identify the minimum equipment to demonstrate a low cost process to produce NHC at a rate of 4000 lbs/300 stream days/year and demonstrate this process. Existing contractor equipment may be used to demonstrate the decaborane to NHC conversion process."

> "Design and identify additional equipment necessary to support low rate production of 9000 lbs of NHC per year based on 300 stream days per year of operation."

> "Design and identify additional equipment to expand production of NHC to 30,000 lbs/300 stream days/year."

Callery's approach to meeting these objectives was based primarily on prior process development studies and extensive commercial production experience with a variety of boron chemicals, including NHC. This experience had demonstrated that for any process involving boron hydride based materials safety was of paramount importance, with operational feasibility and cost following in that order. This philosophy, employed in all of Callery's production operations, has resulted in over 11 years of commercial operation with no lost time from accident or toxic exposure.

Callery's selected process concept for low cost production of NHC from diborane starting material involves two major process steps: (1) conversion of diborane (B2) to decaborane (B10); and (2) conversion of B10 to NHC. At the outset of this facility design effort, Callery had partially completed a process development study, funded under Army Contract DAAK40-75-C-1243, which provided a data base for design of the B2 to B10 process step. This step involves vapor phase pyrolysis of diborane at moderately elevated temperature ($\sim$200°C) and near atmospheric pressure (3-5 psig) in a unique convective circulation reactor. These process conditions meet the desired sarety criteria and also provide a high B10 content solid product that does not require high vacuum sublimation purification.

The second process step, conversion of B10 to NHC, was developed by in-house Callery laboratory and engineering studies from a laboratory recipe provided by the Army. These process improvement studies resulted in a commercial scale process with B10 to NHC yields of the order of 50 percent of theory, compared with only 30-35 percent yield from the original lab procedure.

DESIGN BASIS

General

The overall NHC facility design basis includes the following items set forth in the Contract TR 6116:

> The designed modular carborane facility shall have a maximum production capacity of 30,000 lbs NHC per year. The facility shall have a 15 year economic life and its annual production rate shall be based on an operating year of 300 stream days. The n-hexyl carborane (NHC) produced by this facility shall conform to the NHC specification Nr. 1003, dated 14 August 74. The diborane feedstock shall be a minimum of 96 weight % pure diborane in the liquid phase and shall contain no more than a maximum of 2% noncondensables.
>
> The design shall be such that the facility constructed shall be in accordance with all applicable federal, state, local and industry codes, standards and schedules.
>
> The contractor shall meter all utilities used by the NHC facility and shall provide meters for this purpose separate from his own meters.

Other technical requirements and criteria centered around operational safety and environmental acceptability. Of major concern with regard to these parameters is the B2 to B10 process step which presents the principal toxicity exposure hazard and environmental emission problems. In the B10 to NHC process step, the borane vapor toxicity hazard is essentially eliminated by the first reaction step and thus from that point, the principal hazards and emission control problems are those presented by flammable organic solvents.

The critical nature of the B2 to B10 process operations requires that this process meet criteria developed from Callery's long and successful experience in the manufacture of diborane and diborane derived products. These criteria include:

1) Processing of diborane at relatively low temperatures and, more importantly, at low pressures, preferably at slightly above atmospheric pressure to prevent air leakage into process equipment.

2) High ultimate conversion of diborane to eliminate the need for difficult, hazardous and costly cryogenic recovery operations and to minimize emission control problems.

3) Diborane handling and processing operations under conditions that minimize the physical inventory of diborane and other volatile boranes in the process area.

The selected B2 to B10 process meets these criteria and additionally provides a safety bonus by yielding a high B10 content solid product that does not require the high vacuum sublimation purification typically required of B10 produced by other routes.

<u>B10 Process</u>

The design basis for the B10 process was derived from pyrolysis reactor development studies which provided yield-feed rate data for both 1 in. and 2 in. ID reactor sizes and for both single and two state operation. Figure 2 shows schematically the arrangement of a single convective circulation reactor loop.

Diborane pyrolysis proceeds by a complex mechanism involving a large number of both stable and transitory borane intermediates. For example, Long (1970),[1] in a review of diborane pyrolysis identifies at least 10 intermediate boranes and more than 20 reaction steps that may be involved in formation of decaborane. Decaborane and the polymeric hydride, $(BH)_x$, are solids at ambient temperatures and are thus readily isolated

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1. Long, L.H., "The Mechanisms of Thermal Decomposition of Diborane and of Interconversion of the Boranes", J. Inorg. Nucl. Chem., 1970, Vol 32, pp 1097-1115

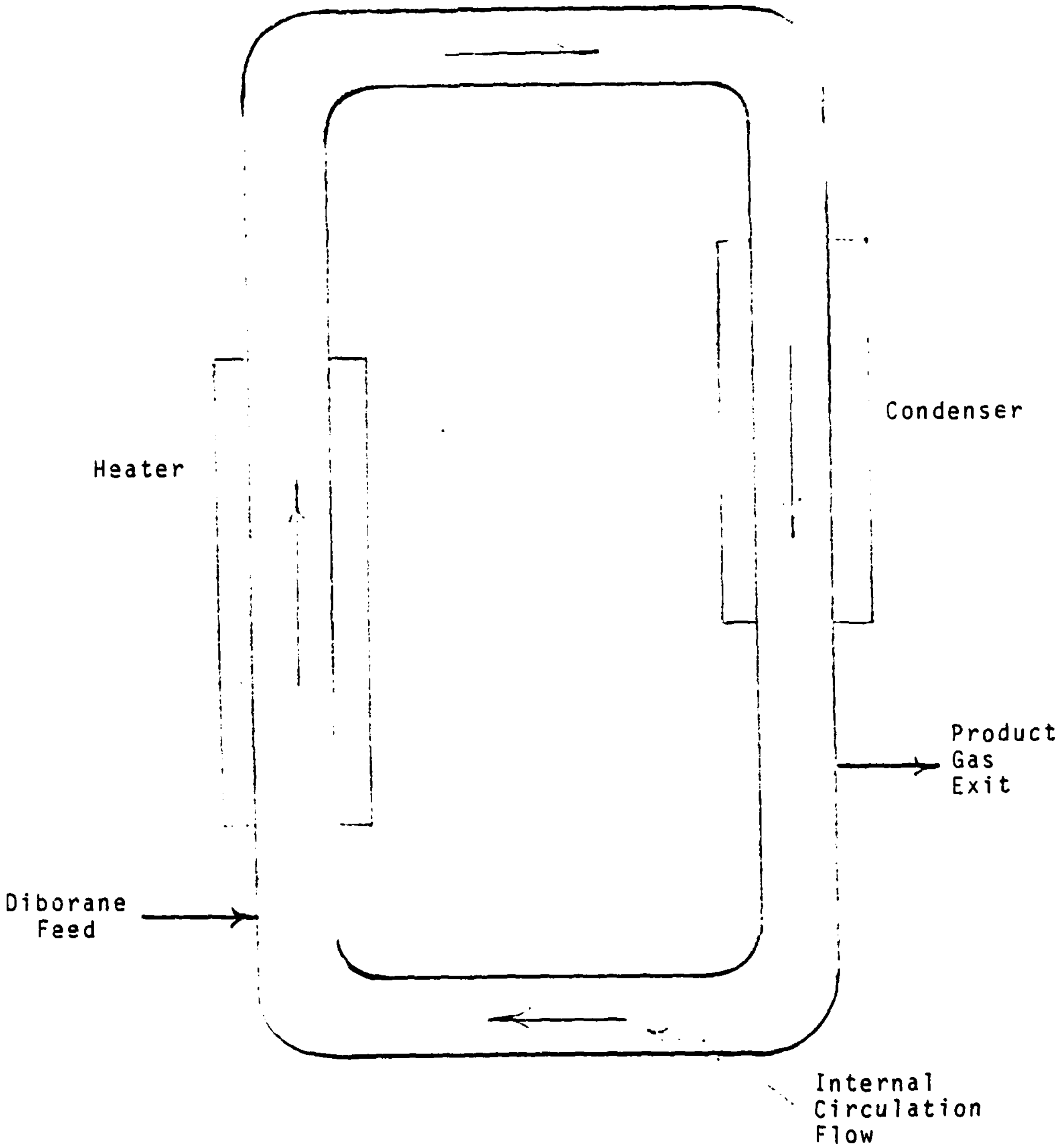


FIGURE 2 - SCHEMATIC CONVECTION LOOP REACTOR

from the other volatile borane intermediates. Under pyrolysis conditions above about 150°C in the convective loop reactor, ultimate products are primarily B10 and (BH)x.

To avoid complications arising from reaction mechanism interpretation, the experimental yield data obtained from the reactor development studies were expressed in terms of the total diborane feed, as percent of the simplified theoretical reaction

$$5B_2H_6 \longrightarrow B_{10}H_{14}+8H_2.$$

For this reaction, the theoretical yield of B10 is 0.88 lb of B10 per lb of B2. Thus, an experimentally reported yield of 50 percent would mean formation of 0.44 lb B10 per lb of B2 fed to the reactor.

Pyrolysis data correlation indicated that yields of B10 and the undesirable co-product (BH)x are primarily functions of B2 feed rate, pyrolysis temperature (measured as axial gas temperature in the heater section) and the convective recirculation rate. Feed rate and gas temperature are independent variables while recirculation rate is a complex function of gas composition, temperature and relative elevations of heater and condenser.

Typical experimental B10 yield variation with B2 feed rate is illustrated in Figure 3 for two stage operation of the 1 in. and 2 in. ID reactor combinations at similar pyrolysis temperatures. It was also shown that by correlating B10 yield with B2 feed rate expressed as lb per hr ft^2 of heated reactor surface, internally consistent correlation could be obtained for both 1 in. and 2 in. scale reactors. Individual stages of two stage operation were similarily correlated by making some simplifying assumptions as to the composition of the second stage feed and the relative split of (BH)x formed in each stage. This method of data correlation is illustrated in Figure 4 for overall two stage B10 yield and in Figure 5 for individual stagewise B10 yield.

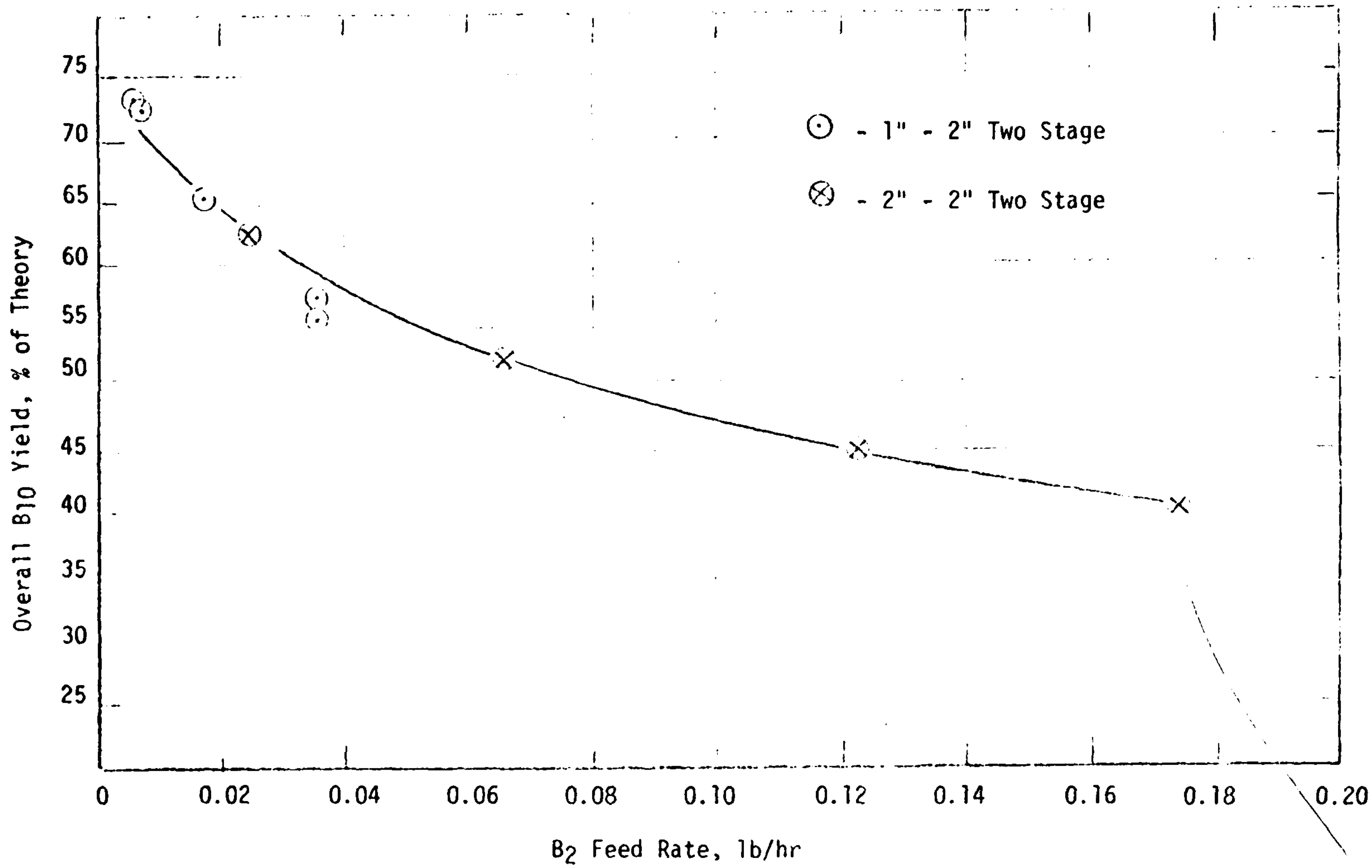


FIGURE 3 - TYPICAL TWO-STAGE YIELD VARIATION WITH FEED RATE

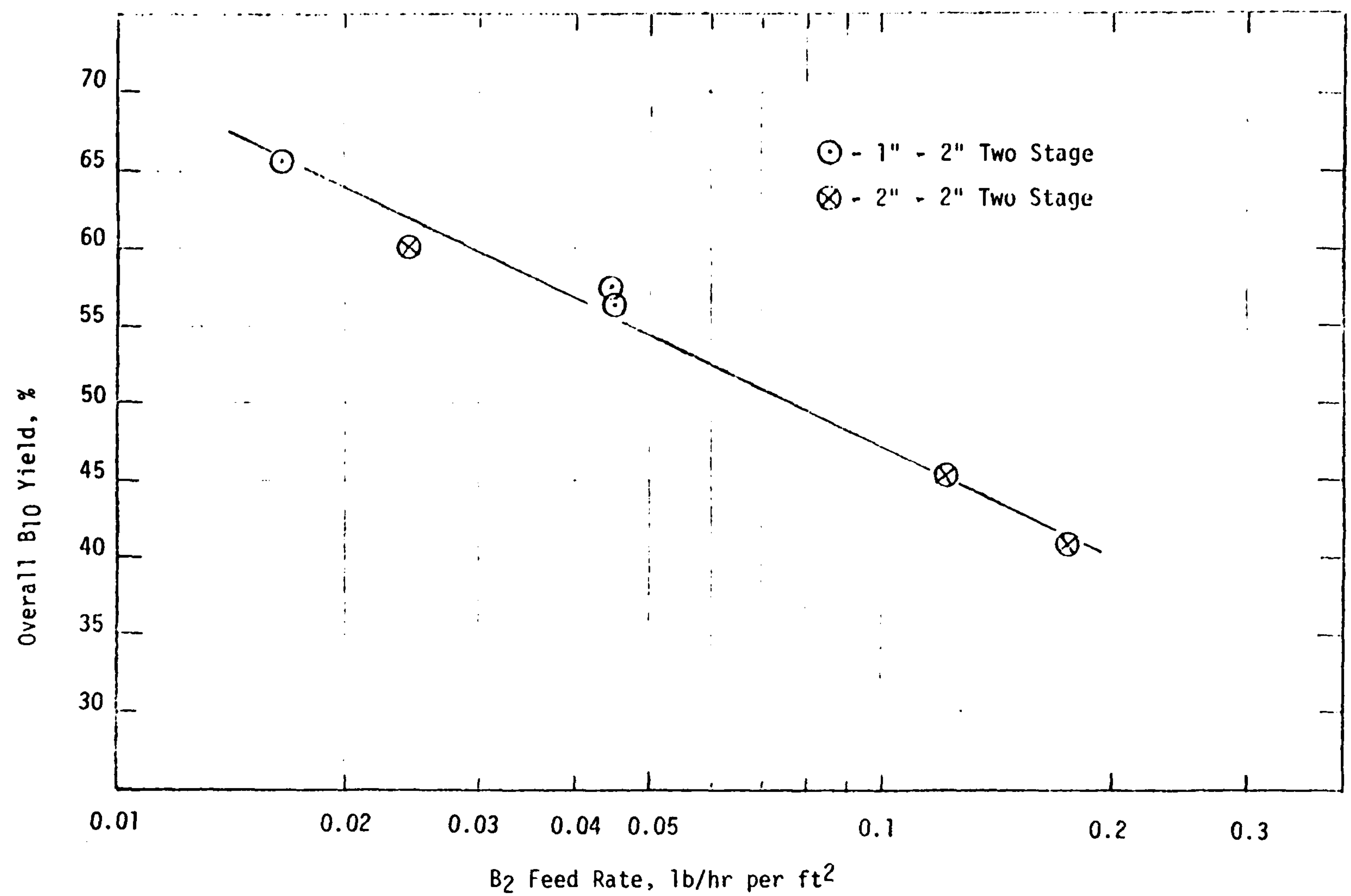


FIGURE 4 - OVERALL TWO STAGE YIELD-FEED RATE CORRELATION

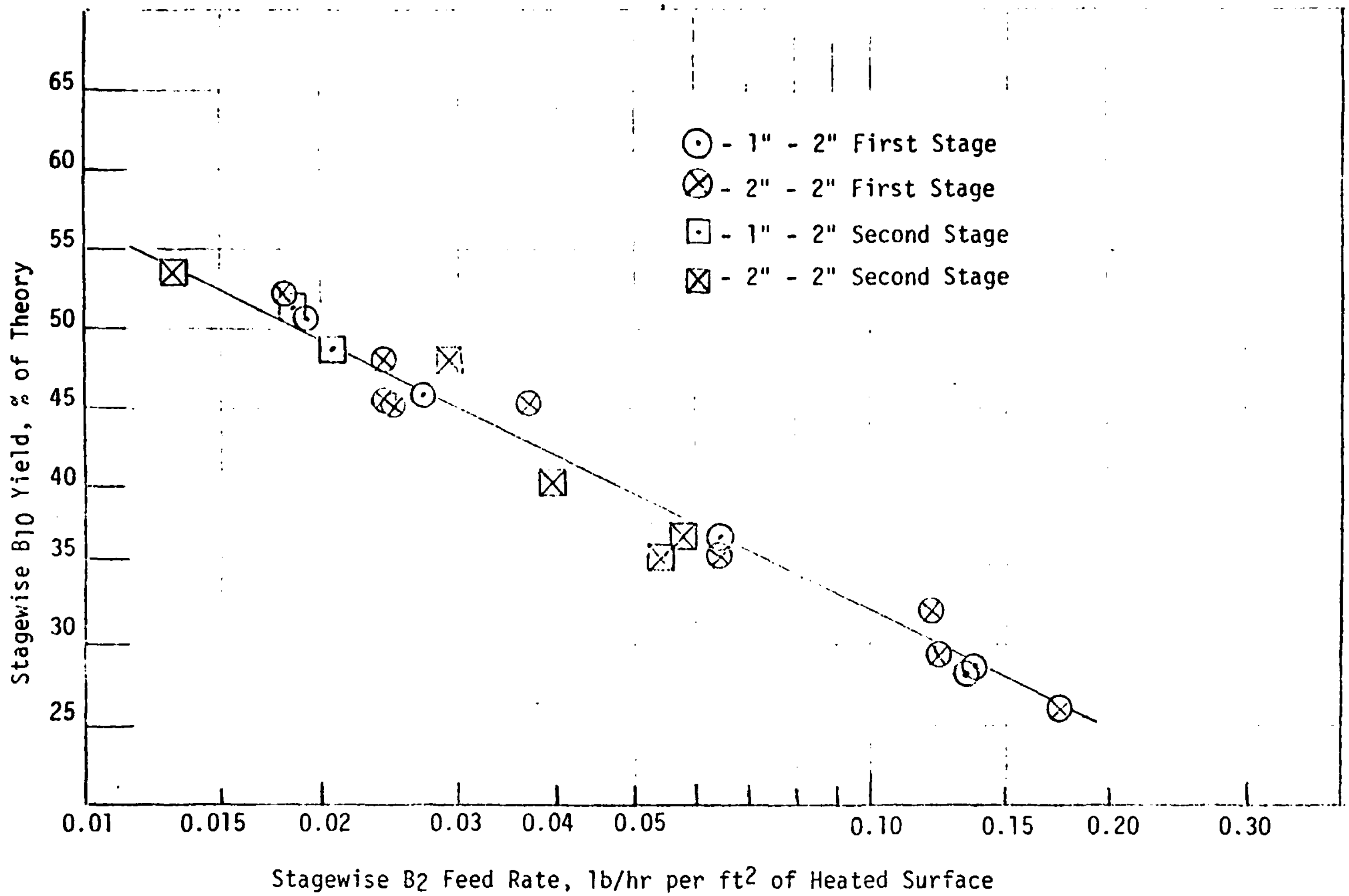


FIGURE 5 - STAGEWISE YIELD-FEED RATE CORRELATION

Engineering analysis of the experimental yield data, overall B2 utilization and other technical requirements resulted in an optimum unit reactor configuration consisting of three stages of 4 in. ID loops, having a nominal 48 in. long heated section or 4.2 ft^2 of heated surface. The variation of B10 yield and production rate with B2 feed rate for this selected unit reactor is illustrated in Figure 6. At the design feed rate of 0.84 lb B2/hr (equivalent to 0.2 lb/hr ft^2), the unit reactor has the design capacity equivalent to 2500 lbs NHC/300 SD. Thus, for 30,000 lbs NHC/yr design capacity, 12 unit reactors in parallel are required.

Selection of this optimum number of reactors was based on tradeoff analysis involving B2 utilization and capital and operating costs of multiples of unit reactors operating at various B2 feed rates. Details of this tradeoff analysis are given in Appendix A.

The resulting design basis for the B10 process may be summarized by the block diagram of Figure 7 which gives the calculated material balance around a three stage unit reactor. Engineering design of an individual reactor stage is shown in Figure 8.

NHC Process

The design basis for the B10 to NHC process was derived by scale-up of Callery's existing commercial production process. Since early 1972, Callery has been producing NHC for government usage. Starting with a laboratory recipe provided by the Army, the process was tested at laboratory scale and subsequently scaled to multi-pound batch production levels. In 1973 increased production requirements led to an in-house study to improve process yields and reduce costs. As a result of process modifications, NHC conversion yield from B10 was increased from near 30 percent to near 55 percent. These improvements were incorporated into production early 1974 with verification of yield improvement at nominally 16 lb batch production levels. Over 300 lbs of NHC has been made by Callery's process, all of it meeting Army product specifications.

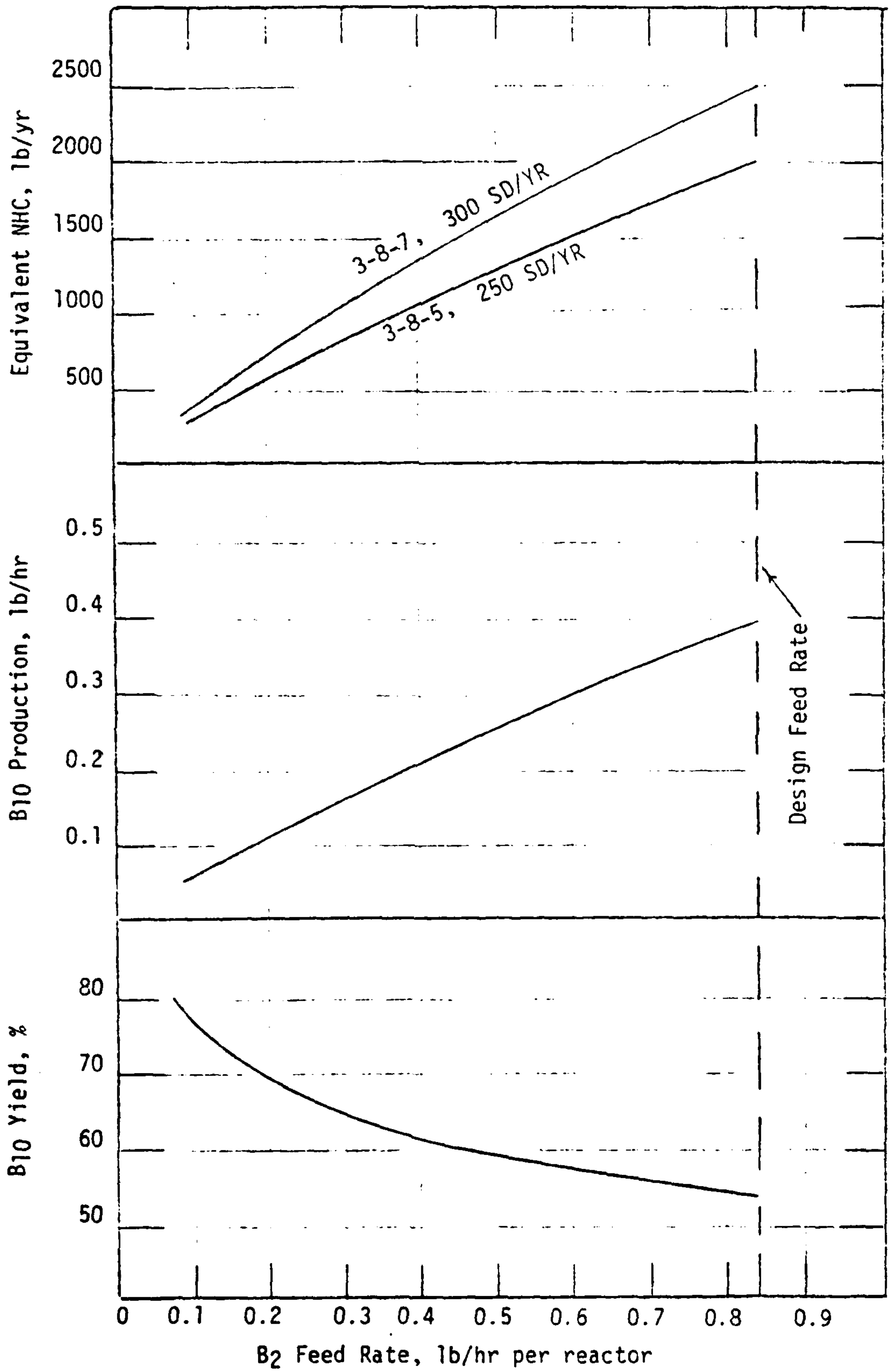


FIGURE 6 - VARIATION OF YIELD AND PRODUCTION FOR 3-STAGE 4" UNIT REACTOR

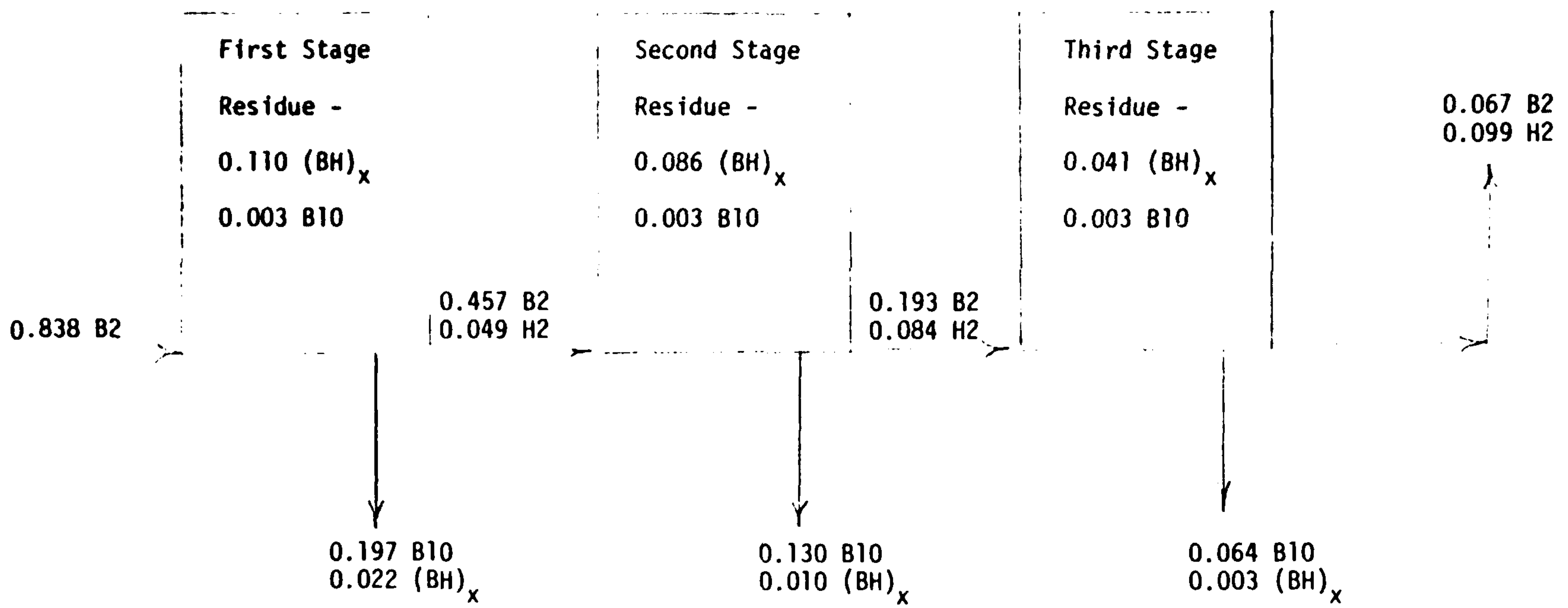
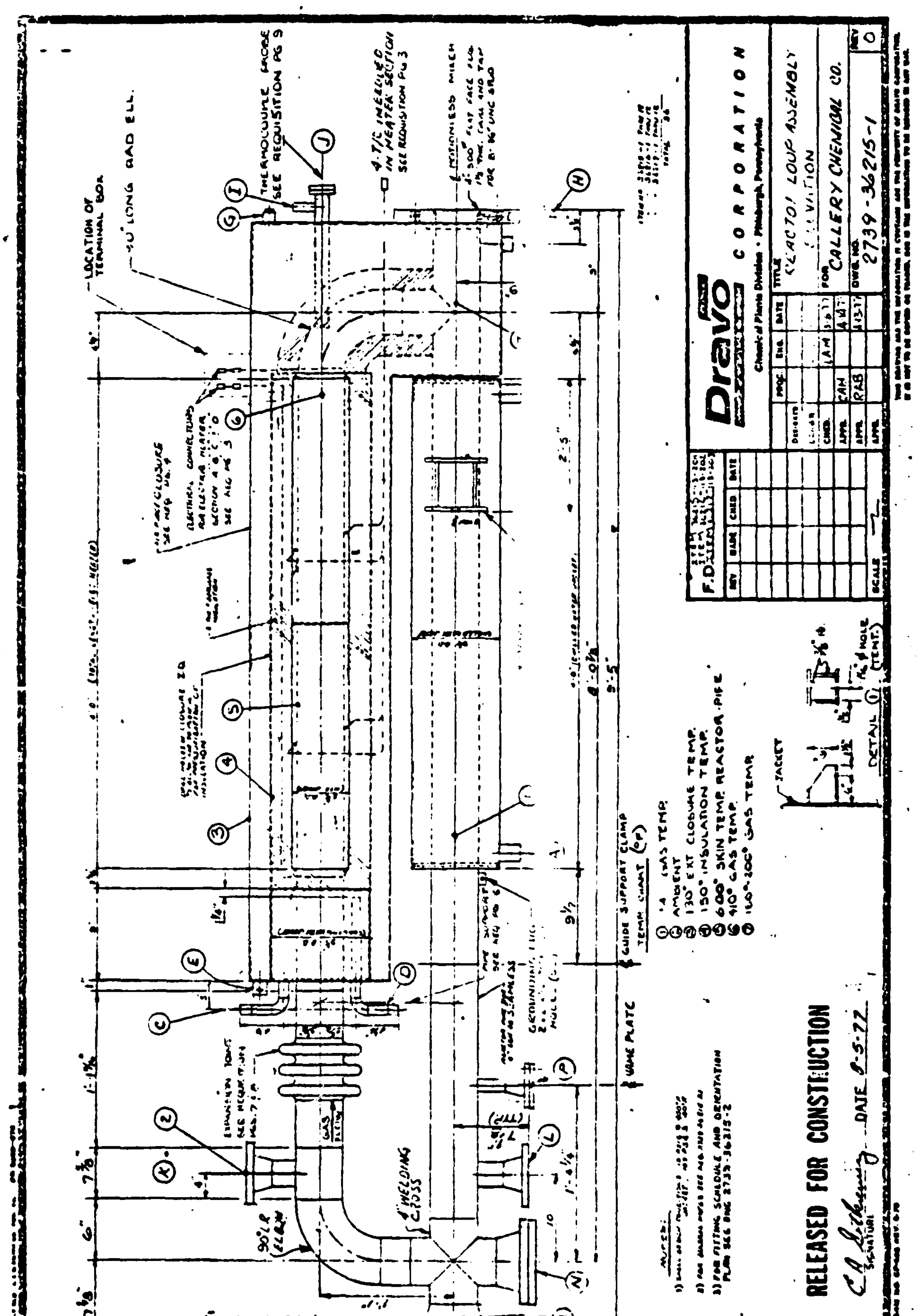


FIGURE 7 - BLOCK DIAGRAM AND MATERIAL BALANCE FOR 4" ID UNIT B10 REACTOR (QUANTITIES IN LBS/HR)


ELEVATION
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Dravo CORPORATION
Chemical Plants Division • Pittsburgh, Pennsylvania
REACTOR LOOP ASSEMBLY
CALLERY CHEMICAL CO.
2739-36215-1
THERMOCOUPLE PROBE SEE REQUISITION PG 9
LOCATION OF TERMINAL BOX
90° LONG RAD ELL.
GUIDE SUPPORT CLAMP
TEMP. CHART
AMBIENT
130° EXT CLOSURE TEMP.
150° INSULATION TEMP.
600° SKIN TEMP. REACTOR PIPE
410° GAS TEMP.
VANE PLATE
DETAIL

FIGURE 8

In brief, crude NHC is produced by sequential batch-wise solution processing, initially converting B10 to the sulfide ligand with subsequent reaction with 1-octyne to obtain crude NHC. Key parameters in achieving high conversion yield are reactant and solvent ratios, addition rates and time-temperature conditions.

Subsequent process steps involve extraction of NHC from its waste co-products with pentane, purification by aqueous salt solution washing, solvent stripping and high vacuum distillation. To assure production of NHC with requisite propellant formulation and storage life characteristics, all NHC delivered for propellant usage has been doubly distilled with an intervening heat soak or pyrolysis step. This requirement has been incorporated into the facility design to assure product quality.

Using the present Callery commercial process as the design basis for the NHC process, the design yield based on the simplified overall theoretical reaction

$$\underset{(B10)}{B_{10}H_{14}} + \underset{(1\text{-octyne})}{C_8H_{14}} \longrightarrow \underset{(NHC)}{B_{10}H_{11}C_2C_8H_{13}} + 2H_2$$

is 52 percent, equivalent to 0.97 lb HNC per lb B10. For the 30,000 lbs NHC/yr design, process batch size is set for production of 100 lbs NHC per stream day, requiring 103 lbs B10/SD.

PROCESS DESCRIPTION

General

The proposed facility will produce NHC at a rate of 30,000 lbs/yr starting with diborane (B2) and certain organic raw materials and solvents. As illustrated in the process block schematic, Figure 9, the facility consists of two principal process areas, namely:

a. The B10 area in which B2 is converted to B10 by continuous vapor phase pyrolysis; and

b. the NHC area in which B10 is converted to NHC by sequential batch solution processing and purification.

Supporting facilities for the process operations include a drum storage area, tank farm, utilities area, vent system and waste disposal area, and change house for the operating personnel. Process areas and supporting facilities are arranged for operating convenience and safety as illustrated by the plot plan, Figure 10.

Off-site facilities connected to the production facility include natural gas, electricity, telephone, potable and process water, fire water, sanitary sewers and diborane supply. These off-site requirements are provided by appropriate connections to existing facilities of the Callery/Mine Safety Appliances Company plant. Incinerator quench water requirements will be provided by connection to a well to be drilled near the present Callery/MSA main electrical substation. Sanitary wastes are piped to the existing Callery/MSA waste treatment facility.

Raw Materials and Storage

Principal raw materials and solvents are listed in Table 1 along with some pertinent physical properties. Material usages are shown on the process flow diagrams, Figures 11 through 15, which follow the process description.

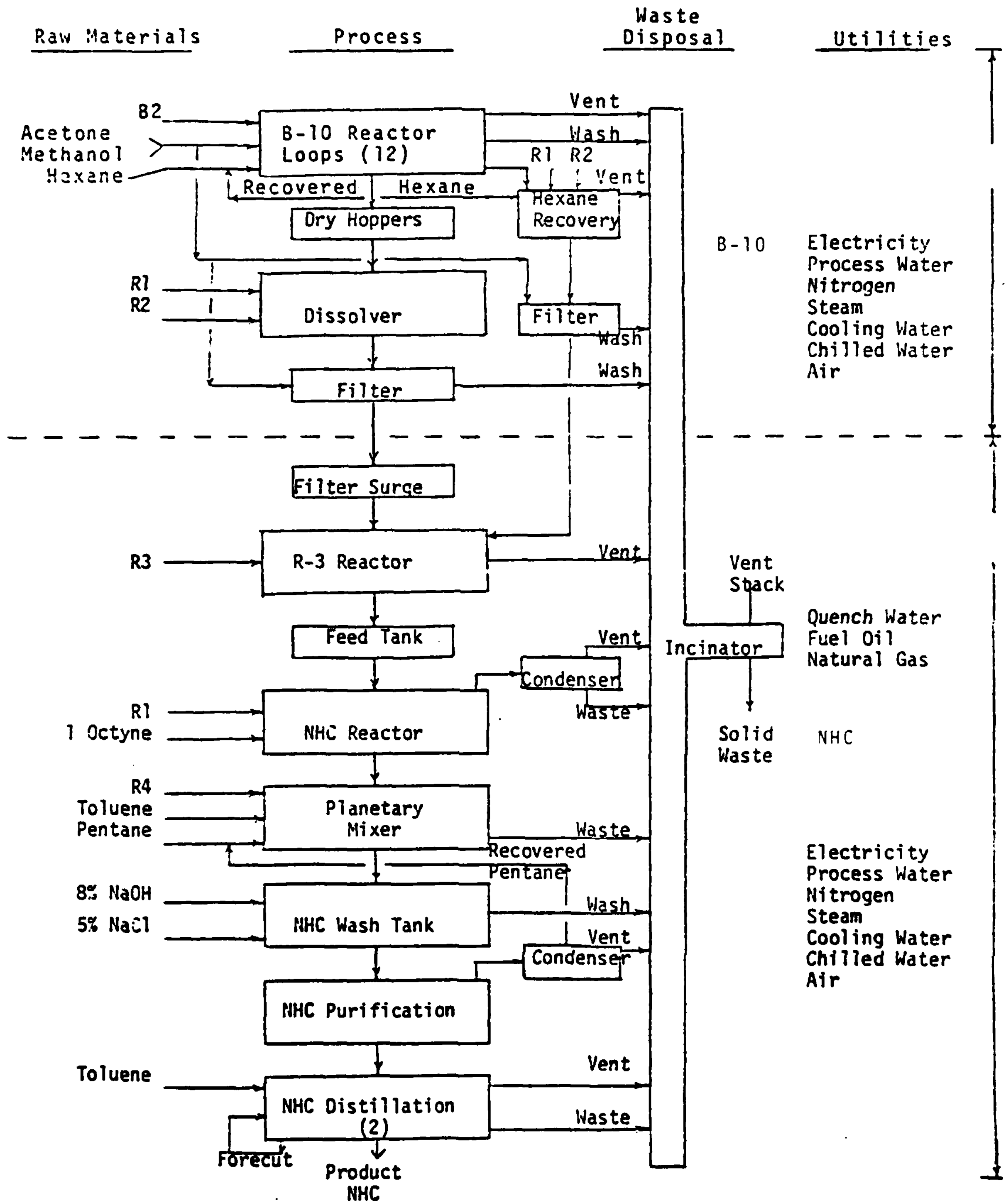
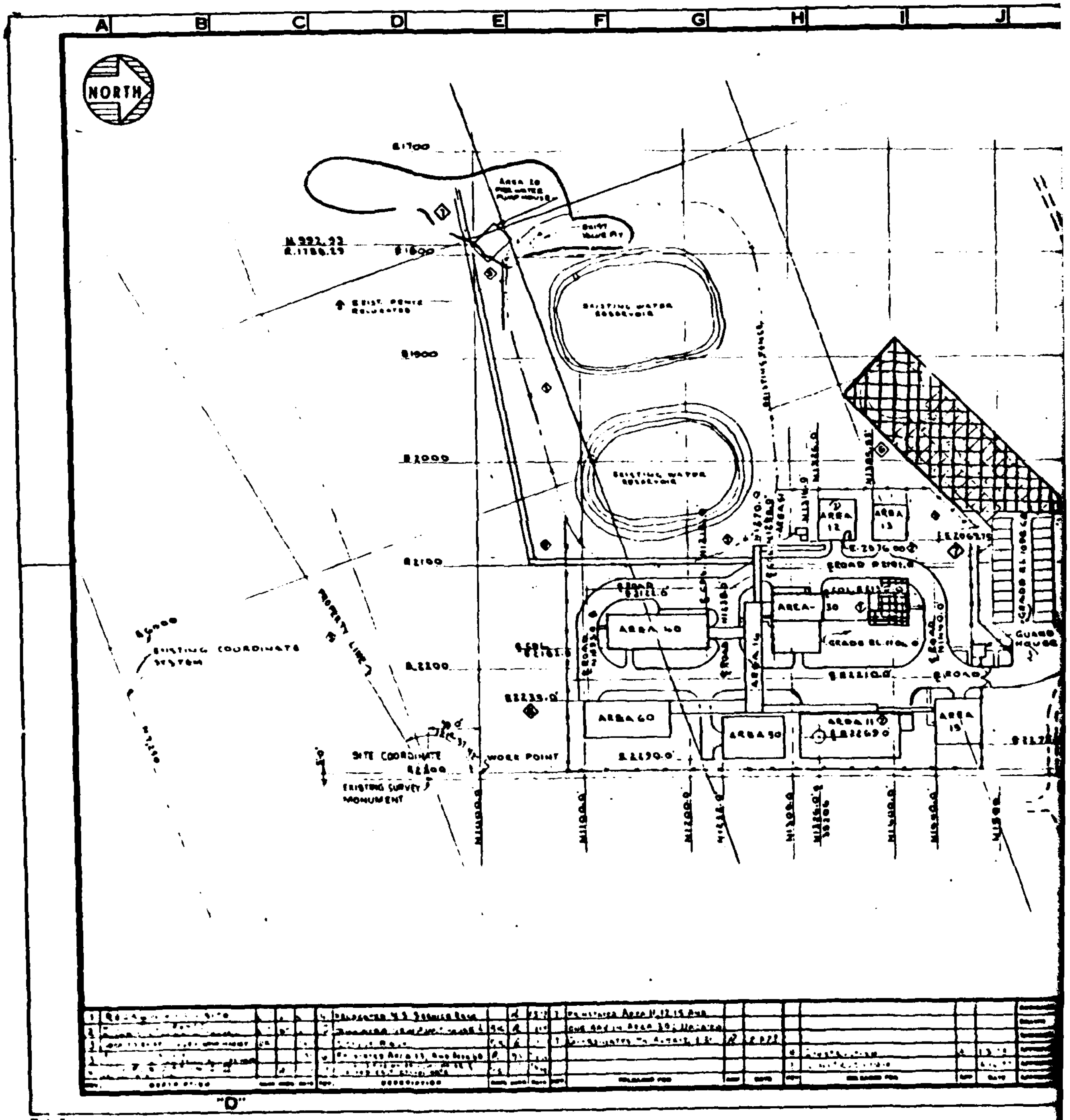


FIGURE 9 - NHC FACILITY BLOCK DIAGRAM



A
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EXISTING WATER RESERVOIR
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AREA 30
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AREA 13
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SITE COORDINATE
WORK POINT
EXISTING SURVEY MONUMENT
GUARD HOUSE
"D"

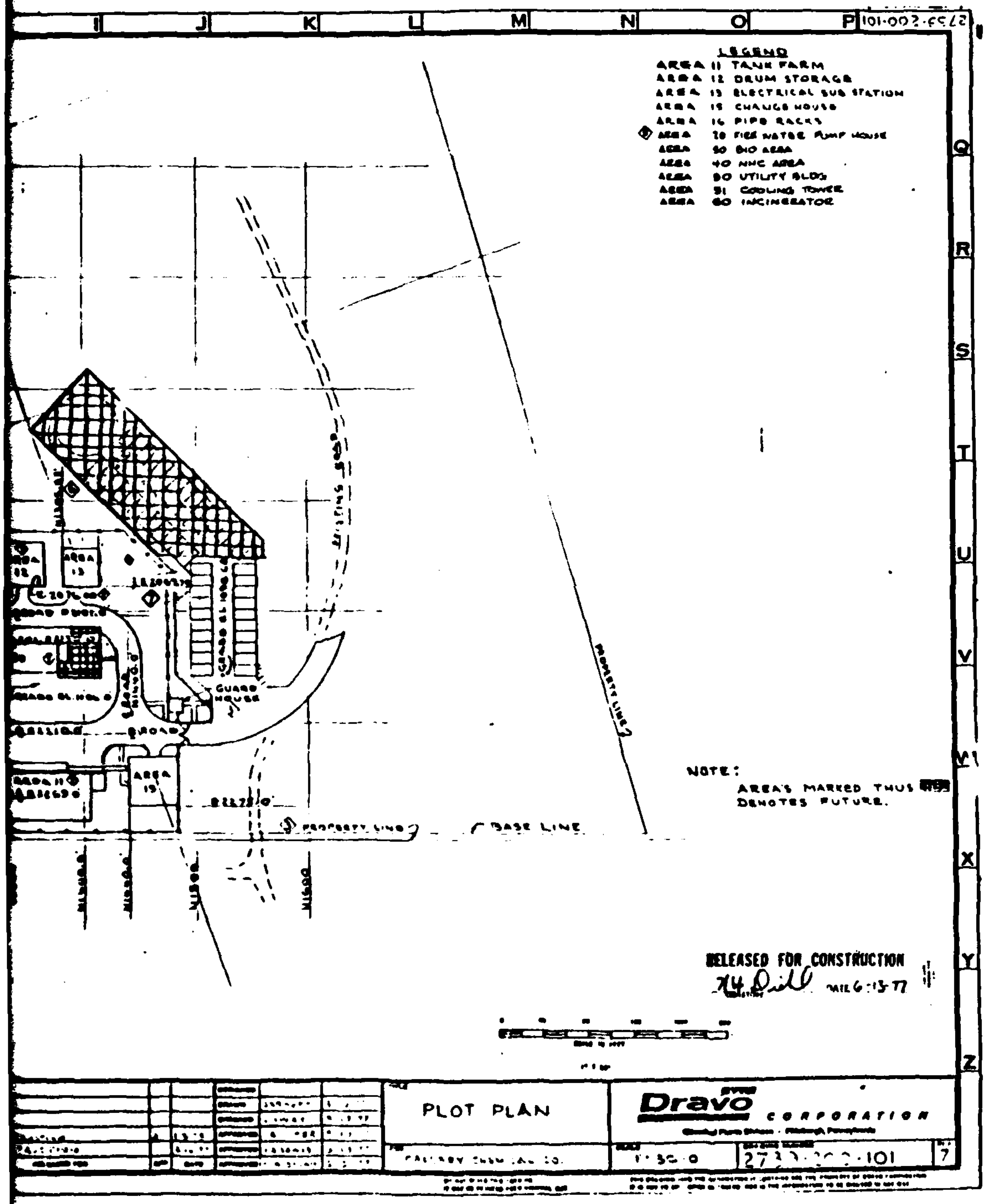
LEGEND
AREA 11 TANK FARM
AREA 12 DRUM STORAGE
AREA 13 ELECTRICAL SUB STATION
AREA 15 CHANGE HOUSE
AREA 16 PIPE RACKS
AREA 20 FIRE WATER PUMP HOUSE
AREA 30 BIO AREA
AREA 40 NHC AREA
AREA 50 UTILITY BLDG
AREA 51 COOLING TOWER
AREA 60 INCINERATOR
NOTE:
AREAS MARKED THUS DENOTES FUTURE.
GUARD HOUSE
PROPERTY LINE
BASE LINE
RELEASED FOR CONSTRUCTION
PLOT PLAN
Dravo CORPORATION
2733-200-101
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TABLE 1: PROCESS MATERIALS

Material	State	Specific Gravity (Water-1.0)	Melting Point (°F)	Boiling Point (°F)
B2 (Diborane)	G	---	-266	-134
B10 (Decaborane)	S	---	211	416
R-1 (Dibutyl Ether)	L	0.77	-139	286
R-2 (Dioxane)	L	1.03	50	214
R-3 (Dibutyl Sulfide)	L	0.84	-112	360
R-4 (Pyridine)	L	0.98	- 44	240
1-Octyne	L	0.75	-110	260
Acetone	L	0.79	-138	134
Methanol	L	0.79	-144	148
Hexane	L	0.66	-140	156
Pentane	L	0.63	-202	97
NHC (n-hexyl carborane)	L	0.89	- 76	---

Drummed raw material will be stored in the drum storage area and transported by fork truck to centralized transfer stations adjacent to the B10 and NHC process areas. In-plant storage of drummed material provides for 30 days operating supply.

Bulk storage material will be received by tank truck, nominally 4000 gallons per delivery. These materials are stored in the tank farm area and piped to the appropriate usage points.

Miscellaneous materials, such as cooling tower and boiler water treatment chemicals, are stored in the drum storage area. As required, these materials are weighed out in the drum storage area and either hand carried or fork truck carried to the users.

B10 Production

Conversion of diborane (B2) to decaborane (B10) is effected in a parallel group of three stage convective circulation type reactors. Each reactor consists of three loops connected in series, each loop of which is a stage and consists of a vertical heating and a vertical cooling section connected at their tops and bottoms. The heating and cooling sections are arranged to induce a recirculation of the vapor in each loop. The recirculation rate is approximately 15 times the feed rate. The reactor is started up, after purging with nitrogen, by feeding nitrogen at a controlled rate to the first stage and bringing the heater and cooler sections to operating temperature. When the unit is at temperature, the nitrogen flow is replaced by diborane. The diborane is heated and partially converted to B10 and other boron hydride polymer in the vertical section (4 in. diameter by 4 ft long) of the stage by an electric heater. The temperature of the material at the top of the heating section is approximately 410°F (210°C). It is cooled by ambient conditions in the top horizontal run section to 180-200°F and then enters the top of the vertical cooling section. This cooling in the horizontal section allows polymeric boron hydrides to solidify out while the B10 remains a vapor.

In the second vertical section of the loop, the B10 is desublimated by chilled cooling water. This condensing section has a motionless mixer which may be either continuously or periodically rotated to dislodge solid B10. The vapor leaves the condensation section at 54°F (12°C), part recycling to the first stage heater and part proceeding to the second stage. Solid B10 falls to a collection hopper. The collection hoppers are portable containers sized to handle the B10 produced between washouts of the loop as described below.

The boron compounds proceed through the second and third stages in the same manner as the first stage. These stages are identical in construction and similar in temperature profile to the first stage. The exit vapor from the third stage is exhausted through one of two micrometallic filters to a B10 vent header which discharges to the waste incineration system. Two vapor filters are provided to insure completion of a cycle without shutdown due to a filter being loaded. Provision is made so that in the event the on-stream filter becomes loaded, it can be pulsed with nitrogen and the solids blown back to the loop. In the event this does not clean the filtering surface flow can be switched to the second unit, the first unit purged and the unit removed for cleaning with solvent. After cleaning, the unit can be reinstalled, purged with nitrogen and then put back into operation when needed. At the completion of the reactor cycle, this filter can be washed in place along with the reactor loops.

At the end of a loop run, the loops undergo a purging procedure. The purging operation of a reactor consists of several steps. First, the diborane flow is shut off and replaced by nitrogen at a rate twice that of the diborane flow. The heating and cooling sections are maintained at their operating temperatures to provide recirculation. The gases from the third stage are discharged to the B10 vent header. This operation is continued until the reactive materials have been displaced by

nitrogen. During the latter part of the purge, the heater is then turned off and the hot section down to ambient temperature. The hopper connection is purged by closing the valves between the loops and the hoppers, then connecting the distance piece between the valves to the high velocity vent header which discharges to the incineration system and purging with nitrogen. After the nitrogen purge, the connection is broken and a suction maintained on the opening by the blower in the high velocity vent header system until the opening is blanked off.

After this purging operation, the hoppers containing the product B10 are transferred by means of a lift truck to a weight scale. After weighing, they are transferred to and emptied into a dissolving tank. After the B10 in the portable hoppers is dumped into a dissolving tank, Reagents R-1 and R-2, which have been pumped from their respective drums into measuring pots, are added. The solution is agitated for at least 15 minutes with low pressure steam maintaining the temperature at 100°F. A sample is taken of the solution which has been proportioned to have a slight excess of B10. After the sample is analyzed, R-1 and R-2 are added to bring the final solution to the proportions based upon the total B10 available.

Also after the purging operation, the loops undergo a two step washing operation. In the first step, the loop system is flooded with hexane, which is added from a charging tank, to dissolve B10 still clinging to the walls of the loop. Venting of the system is accomplished through the three lines at the mixers. Nitrogen is bubbled through the system to aid in dissolution. After one-half to one hour of agitating the hexane, the hexane is drained and pumped through a micrometallic filter to extract undissolved $(BH)_x$ impurities into the hexane hold tank. Makeup hexane is added to the hold tank from drummed material.

When the hexane wash stream has become saturated with B10 (4% by weight), the hexane is diverted to the wash system

kettle. Approximately 67 gallons of saturated hexane can be processed at one time. This amounts to approximately one-half the volume of hexane in the hold tank and approximately 33 percent more than the volume required for washing a loop. The temperature is kept low (102°F) to prevent degradation by maintaining a pressure of 5 psia. Product hexane is condensed in a water cooled exchanger and collected for transfer back to the hexane hold tank. Uncondensed vapors are pulled through a cold trap maintained at -108°F (-78°C) before venting. After most of the hexane is boiled off, the unit is shut down until the next batch must be processed. The residue from several batches is collected in this kettle. After the hexane boil off from the final batch, the pressure can be reduced to 3 psia and more hexane removed. The recovered hexane is then pumped to the hexane hold tank, and the pressure is reduced to a vacuum of 1 mm Hg absolute and the solid B10 reduced to dryness. The dry B10 remaining in the kettle is slurried with R-1 and R-2 and sent to the NHC system. The bulk of the hexane is removed in about one hour, and the total kettle time per batch for the last batch is approximately three hours.

The second solvent wash step uses a combination of methanoland acetone in equal proportions. Methanol and acetone are added from their respective tanks to an agitated tank for mixing. When the hexane has been drained from the pyrolysis loop, the methanol-acetone mixture is added to dissolve the $(BH)_x$. After a procedure similar to the hexane dissolution, the methanol-acetone solution is pumped to the process drain tank for disposal by incineration. Two or more methanol-acetone washes may be required for each loop wash depending on the amount of polymer present.

When the reaction of B10 with R-1 and R-2 in the dissolving tank is completed, the reaction product is transferred by means of nitrogen pressure to the dissolver filter. This is a micrometallic type filter in which any polymer present is

filtered out. The filtrate from the filter is collected in the dissolver product received. The filter also drains into this receiver. When a day's production is collected in this receiver the material is pumped to the dissolver surge tank in the NHC system. Since the volume transferred is relatively small compared to the holdup in the line, the transfer line is so arranged that there is a short vertical run of pipe above the pump which connects to a long horizontal run of pipe to the surge tank. This horizontal run is sloped toward the surge tank. At the intersection of the vertical and horizontal runs a nitrogen connection to supply nitrogen for blowing all the liquid in the horizontal run to the surge tank and all the liquid in the vertical run into the dissolver product receiver. This not only provides for transferring a full NHC feed batch but prevents any possible hydrogen formation which may occur when the solution sets for a period of time from collecting in the lines. Hydrogen formation, therefore, is limited to the two tanks which are properly vented for this.

A filter wash system is provided for washing the polymer from the dissolver and borane filters. This consists of a filter wash tank and filter wash recirculation pump. The wash tank is charged with methanol-acetone solution. Before use, this wash solution is chilled in this tank to 50°F by means of chilled water. This is necessary to prevent overheating this wash liquor from the exothermic reaction which occurs when the polymer on the filters reacts and dissolves in the wash liquor. The chilled wash liquor is recirculated for the wash tanks through the filter and back to the tank until all the polymer is removed. This requires several minutes. The wash liquor flow through the filter is opposite of that of the feed so a backwashing effect is obtained. When washing is complete the filters are drained and then purged with nitrogen. The spent wash liquor is then transferred to the process drain tank for disposal by incineration. Each filter is washed after each batch of dissolver product or hexane

loop wash batch is filtered. The filters are washed on alternating three hour cycles.

NHC Production

The production of n-hexyl carborane (NHC) from decaborane (B10) is undertaken in a two-step batch reaction. Dissolved B10 from the dissolver and from the hexane wash kettle is received in separate agitated surge tanks. The dissolver product surge tank holds one day's production of B10 material in solution. The wash product surge tank holds one wash kettle product batch (based on three wash kettle batches of 67 gallons each every five weeks being evaporated to dryness, dissolved in R-1 and R-2 then transferred to the surge tank). The wash product material is blended as desired with the dissolved material to make up an R-3 reactor charge. A nitrogen blanket at 6 in. H_2O is maintained on the surge tanks and R-3 measuring pot. Level gauges are used to measure the quantities of fluids in the surge tanks and R-3 pot which are the feed materials for the R-3 reactor. One day's production of B10 constitutes an R-3 reactor batch.

The B10 solution is first added batchwise to the R-3 reactor. Fifty percent excess R-3 is then added also batchwise. The nitrogen blanket which is displaced during charging and the hydrogen evolved during the reaction is vented to the NHC vent header. The reaction is slightly exothermic. Cooling water in the jacket of this agitated vessel is used to control the reaction temperature of 100°F. After holding the reaction products in the R-3 reactor for the remainder of a 24 hour day, they are pumped to the NHC feed pot. The reaction occurs over the total 24 hours.

This pot and the R-1 and 1-octyne measuring pots are also blanketed with nitrogen at 6 in. H_2O. The 50 percent excess R-1 and 50 percent excess 1-octyne are measured and gravity fed into the NHC reactor. NHC is produced as the previous reaction product is slowly added over a period of 2 hours. During this

time period, a small quantity of steam is supplied to the jacket to maintain the temperatures of the batch at 266°F. Hydrogen is evolved during the reaction and flows through the NHC condenser, where condensables are condensed out and refluxed back to the reactor, to the incineration system via the NHC vent header.

The kettle is then held for an additional hour at 266°F and under total reflux to complete the reaction. The reactor is then evacuated to 2 mm Hg, and the temperature maintained at 266°F. The vapor, which is primarily R-1, R-2 and excess 1-octyne, which is evolved during this step is essentially all condensed in the NHC reactor condenser. Boilup is carefully controlled because of a foaming problem. A sight glass is provided in the vapor line to detect foam formation. The condensed fluid flows by gravity to the reaction waste receiver while the small amount of non-condensables are pulled through the reaction cold trap filled with dry ice and methanol at -108°F (-78°C) by the vacuum pump. The exhaust from the reaction vacuum pump goes to incineration system via the vent header while the condensed fluid in the reaction waste receiver and reaction cold trap is pumped to the process drain tank from which it is also disposed of in the incineration system.

The product solution left in the NHC reactor is dropped into the planetary mixer. Nitrogen pressure aids in the flow of this viscous solution. While the solution is in the planetary mixer, R-4 from a measuring pot is slowly added. Cooling water in the jacket of the mixer keeps the contents below 113°F (45°C) while the mixer establishes good contact. The NHC vent system removes flammable vapors of this and succeeding steps. Two hours after the R-4 has been added, pentane extraction of the NHC is started. Four separate successively smaller additions of pentane are used to extract the NHC. After each addition, the top layer of pentane and NHC is pumped to the NHC wash tank; the final residue is pumped to the process drain tank after thinning with

toluene. The addition pots have a nitrogen blenket and "breathe" similarly to the previous pots.

The NHC-pentane solution is washed in the NHC wash tank by caustic and salt solutions. Each wash includes addition of the sodium solution plus a volume of process water approximately equal to 75-80 percent of the wash solution. Two additions of 8 percent caustic solution are prepared by diluting 50 percent caustic in the caustic dilution tank. Two additions of 5 percent sodium chloride are prepared by dissolution in the salt dilution tank. Each addition of wash solution is followed by 15 minutes of agitation and 15 minutes of settling. Then the bottom layer is drained through a flow glass to the wash recycle pump which discharges it to the process drain tank. As the change in phase is observed in the flow glass, the fluid is diverted to the NHC wash hold tank so that it may be recycled. After the four washes, the NHC-pentane solution is pumped to the NHC purification system. Provision is made so that the second washes of both brine and caustic can be transferred to the measuring pots for use as the first wash if desired.

The NHC purification system consists of an atmospheric batch distillation unit and two vacuum batch distillation units, one of which is a spare. The atmospheric distillation unit consists of the hot water heated NHC purification kettle, a packed tower, condenser and receiver. The bulk of the pentane is distilled off in this unit which operates at a kettle temperature of 100 to 140°F and a reflux ratio of one to one. Distillation time is 5 hours. The recovered pentane product which has been cooled to 70°F in the condenser, is collected in the pentane receiver from where it is pumped back to the pentane storage tank.

The residue from the atmospheric distillation which consists of NHC, pentane, and side products is transferred to one of the vacuum distillation units for the final purification step. This is a high vacuum system consisting of an electrically heated kettle, low pressure drop packed tower, condenser, reflux

splitter, receivers, cold trap and vacuum pump. In this unit, the temperature in the still is gradually increased, the pressure gradually lowered. The first overhead cut is a waste cut which contains pentane and other low boiling compounds. This is collected in the waste receiver from which it is pumped to the process drain tank. The second cut is a forecut and contains considerable product NHC. It is held in the forecut hold tank for recycling back to the kettle for processing in the next batch. The third cut is product NHC and is collected in the product receiver. The evaporation is terminated when the temperature is 392°F (200°C) and pressure is 1/2 mmHg. absolute. The purification vacuum pump used in the evacuation is protected from harmful vapors by pulling them through a cold trap filled with dry ice and methanol at -108°F (-78°C).

The residue in the NHC purification still is pumped to the process drain tank for incineration. Toluene aids in this cleaning. Product NHC is transferred by nitrogen pressure and gravity flow to a 55 gallon drum before shipment.

Provision is made for transferring the overhead product streams to the spare still in the event further processing is required.

Utilities

Utilities supplied to the plant will be electric power, natural gas, fuel oil, city water and quench water. The supply systems for these utilities, along with the sanitary sewer system, are shown on Engineering Flow Diagram CPD-2739-117-201 (Appendix B). The city water will be Evans City water. It will be supplied to the plant from the two existing eight inch lines supplying the Callery plant from the existing reservoir. This water will be used for fire-water, service water and potable water. Evans City water will be at ambient temperature and has the following analysis:

Date Sampled	11-23-76
Log No. 76-	3315
pH	7.8
Acidity to PHT, mg/l, $CaCO_3$	4
Alkalinity to M.O., mg/l, $CaCO_3$	30
Total Solids, mg/l	222
Suspended Solids, mg/l	6
Dissolved Solids, mg/l	216
Total Hardness, mg/l, $CaCO_3$	112
Calcium Hardness, mg/l, $CaCO_3$	74
Magnesium Hardness, mg/l, $CaCO_3$	38
Chlorides, mg/l, Cl	30
Sulfates, mg/l, SO_4	41
Total Sulfur, mg/l, SO_4	62
COD, mg/l	0
Total Phosphorous, mg/l, P	0.165
Iron, mg/l, Fe	1.02
Total Chromium, mg/l, Cr	0.00
Hexavalent Chromium, mg/l, Cr	0.00
Total Carbon, mg/l, C	19
Inorganic Carbon, mg/l, C	13
Total Organic Carbon, mg/l, C	6

A new well will be installed to supply the incinerator quench water required for this plant.

Natural gas will be supplied from the existing 25 psig supply header and has a heating value of 1050 BTU/cu.ft. Natural gas will be used for pilots. Heating requirements will be supplied by electric power or by No. 2 fuel oil. This fuel oil has a sulfur content of .5 to 1% by weight.

Electric power is available at 8320 volts, 60 cycle from the existing Callery main transformer substation.

Utilities generated in the plant are:

- 100 psig instrument air
  (used also for plant air)
- 30 psig nitrogen
- 45°F chilled water
- 85°F cooling water
- Process water at ambient temperature
  (city water from break tank)
- 50 psig (sat.) steam

Vent System and Waste Disposal

Since the raw materials used and products generated in this facility are hazardous from both toxic and flammable aspects, a waste system has been developed to incorporate the various materials. The collection of wastes is divided into liquid and vapor streams and further subdivided as follows.

The vapor streams are divided into four categories depending upon location and usage. In the B10 building, there are three vent headers. The B10 vent header receives exhaust flow from the third stage of the pyrolysis reactors as well as reliefs from the reactors and flows where B10 and solvents R-1 and R-2 would be disposed of. The vent header is routed to Seal Pot-1 which contains Drakeol 6 at a level to maintain 6" W.C. back-pressure. The vapor sparges through the liquid and exhausts to the thermal oxidizer of the incinerator. Excess flow into Seal Pot-1 would create enough pressure to divert the excess flow to Seal Pot-2 and overcome its backpressure of 12" W.C. Seal Pot-2 also contains Drakeol as the immersing fluid.

The wash vent header accepts vapors from the reactors when they are being washed, the solvent washing system, and the hexane recovery area. This equipment contains hexane, methanol, or acetone. The vapors in this vent header are separated from the B_{10} vent header to preclude the solvent vapors from entering the reactors and creating an organic-boron vapor. The solvent tanks are padded with nitrogen at 6" W.C. and exhaust upon overcoming the pressure setting of the outlet PCV. Evacuation of the wash system and washing of the reactors releases vapors directly into the header. This header discharges into Seal Pot 3. A Drakeol seal is also provided in this seal pot which maintains the header under a 6" W.C. pressure. Flow to the thermal oxidizer and Seal Pot 2 is the same as for Seal Pot 1. Seal Pot 2 vapor goes to an emergency flare stack.

The third vent system in the B10 building and which is also in the NHC building is the high velocity vent system. The

makeup air for incineration in the thermal oxidizer is provided by a blower which preferentially withdraws from the discrete nozzle connections. Additional air is provided from the atmosphere for proper combustion in the thermal oxidizer. To prevent any air leakage, the B10, NHC and wash vent headers are maintained at 6" W.C. by the addition of nitrogen through a pressure controller to each header.

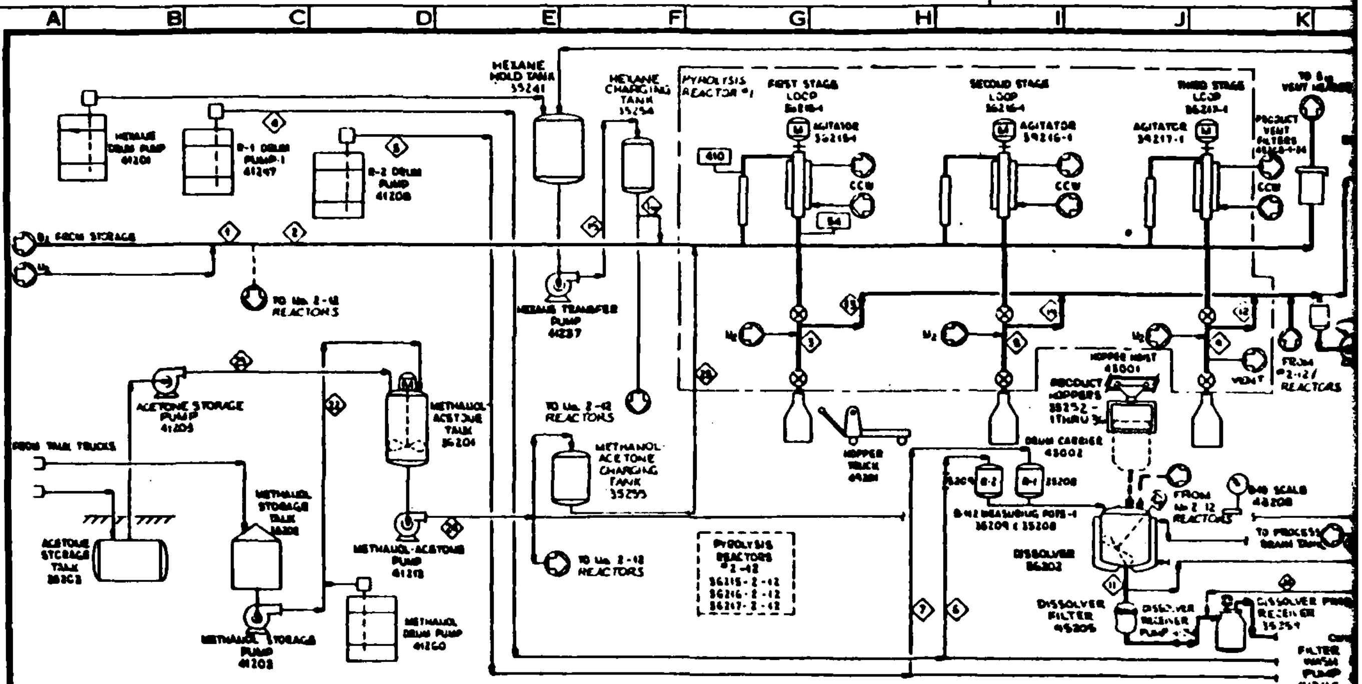
A separate vent header for the NHC building is the NHC vent header. Nitrogen padded equipment and all relief valves exhaust into this vent header. This header, in turn, is sparged into Seal Pot 4 which is also maintained at 6" H_2O back pressure by a Drakeol seal. The seal pot is tied into Seal Pot 2 and the incinerator similarly to Seal Pots 1 and 3.

Liquid feed to the incinerator can be either aqueous or completely organic. Organic feeds are collected in the process drain tank and consist of dissolved boranes in methanol-acetone, condensed wastes from evaporations, residues from operations which may have toluene added to improve fluidity and overflows and drains from the seal pots. The waste stream is pumped from the underground process drain tank to the thermal oxidizer.

The aqueous drain tank collects aqueous wastes from the caustic and brine washes of NHC and the two building sumps. Transfer to the incinerator is identical to the organic system. Aqueous floor washings are collected in sumps from the B10 building and the NHC building and pumped as desired to the drain tank. Vapors from the organic waste tank is reintroduced into Seal Pot 1 while vapors from the aqueous tank is introduced into Seal Pot 4. Level indicators and alarms are provided in the seal pots and incinerator tanks. Pumps are manually operated as desired.

All the waste streams from the seal pots and collection tanks are reduced to a ventable gas stream or a disposable solid in the incinerator unit. This unit consists principally of an oxidizer section, a cooling or quenching section, a bag house, vent stack and an emergency flare stack. It is necessary whenever boron is being disposed of to always have a caustic stream also

fed to the oxidizer so that the boron is converted to a recoverable solid (sodium borate).

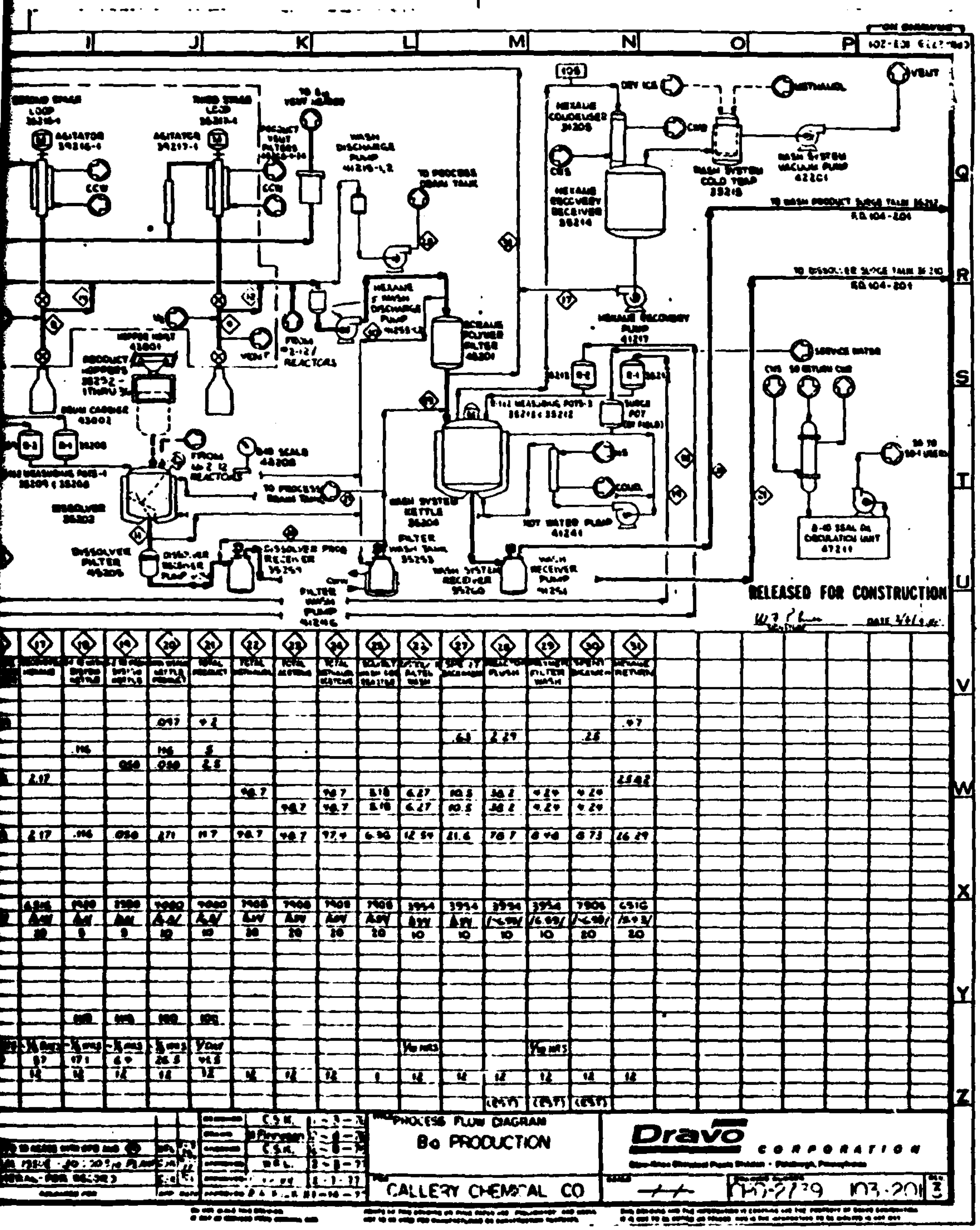


MATERIAL / STREAM No.	1	2	3	4	5	6	7	8	9		11	12	13	14	15	16	17	18	19	20	21	22	23	24
BASIS: 30000 LB/YR/300 DAY YR EACH REACTOR LOOP 2500 LB/YR	TOTAL B FEED	B FEED PER REACTOR	H FROM 1ST STAGE	TOTAL B-1 W/ B-10 ANTA	TOTAL B-2	B-1 TO DISSOLVER	B-2 TO DISSOLVER	H FROM 2ND STAGE	H FROM 3RD STAGE		DISSOLVER PRODUCT	RESIDUE 1ST STAGE	RESIDUE 2ND STAGE	RESIDUE 3RD STAGE	TOTAL HEXANE WASH	HEXANE WASH PER REACTOR	RECOVERED HEXANE	B-1 SETTLE	B-2 SETTLE	SETTLE PRODUCT	TOTAL PRODUCT	TOTAL METHANOL	TOTAL ACETONE	[illegible]
AVERAGE FLOWRATE: LB PER HR																								
B_A	9	.79																						
H_2			.176					.116	.057		9.2	.0027	.0027	.0027	.97	.039				.097	9.2			
$(BH)_x$			.02					.009	.003		.9	.027	.098	.077										
B-1				5.2		5					5							.116		.116	5			
B-2					2.6		2.5				2.6								.058	.058	2.5			
HEXANE												.72	.72	.72	25.95	2.15	2.17							
METHANOL												1.06	1.06	1.06								98.7		98.7
ACETONE												1.06	1.06	1.06									98.7	98.7
TOTAL	9	.79	.196	5.2	2.6	5	2.5	.125	.060		12.1	2.88	2.94	2.92	26.32	2.19	2.17	.116	.058	27.1	11.7	98.7	98.7	97.9
ACTUAL FLOW: LB PER HR	101	.84	.29	1920	2380	1920	2380								6316		6316	1920	2380	4000	4000	7908	7908	79
SP GR/LB PER GAL/LB PER CU FT				AV	AV	AV	AV				[illegible]				AV	AV	AV	AV	AV	AV	AV	AV	AV	AV
GPM				5	5	5	5								30		30	5	5	10	10	20	20	20
MW	22.7	27.7	122.22					122.22	122.22															
SCFM																								
ACFM																								
PRESSURE, PSIG	3	3																						
PRESSURE RANGE, PSIG																								
TEMPERATURE, °F	AMB	AMB	94	AMB	AMB	AMB	AMB	94	94		100							AMB	AMB	100	105			
TEMPERATURE RANGE, °F																								
BATCHES/TIME PERIOD						1/10 HRS	1/10 HRS				1/10 HRS	1/3 SHIFTS	1/3 SHIFTS	1/3 SHIFTS	1/10 HRS	1/3 DAYS	1/6 DAYS	~1/4 HRS	~1/4 HRS	1/4 HRS	1/DAY			
GAL PER BATCH						7.9	2.9				17.3				50	50	87	171	64	26.5	415			
No OF REACTORS FOR FLOW	12	1	1	12	12	12	12	1	1		12	1	1	1	12	1	12	12	12	12	12	12	12	12
TURNOVERS												3 STEPS	3 STEPS	3 STEPS										

3	REV PFD TO AGREE WITH PFD AND (?)	DESIGNED	C.S.K.
2	INITIAL ISSUE ... PLANT	DRAWN	M Finnegan
1	GENERAL FOR RECORD	CHECKED	C.S.K.
		APPROVED	W.F.L.

DESCRIPTION

"D"


RELEASED FOR CONSTRUCTION
PROCESS FLOW DIAGRAM
Bo PRODUCTION
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CORPORATION
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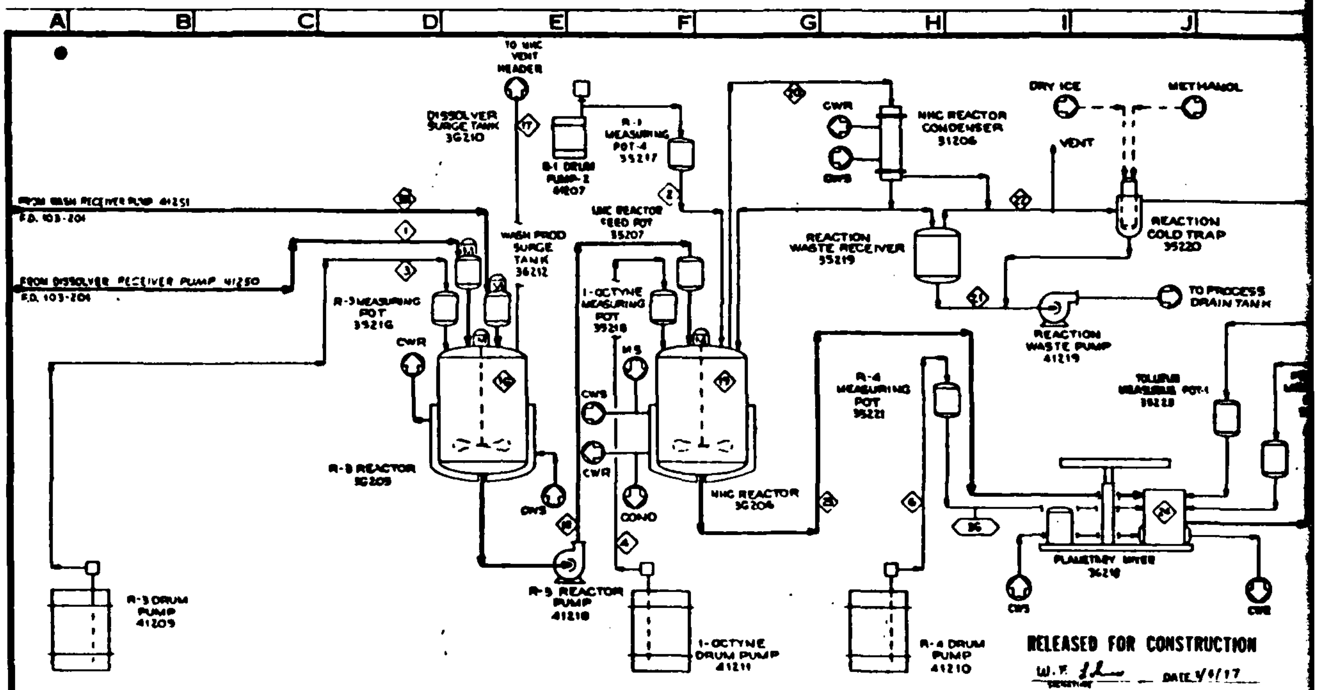
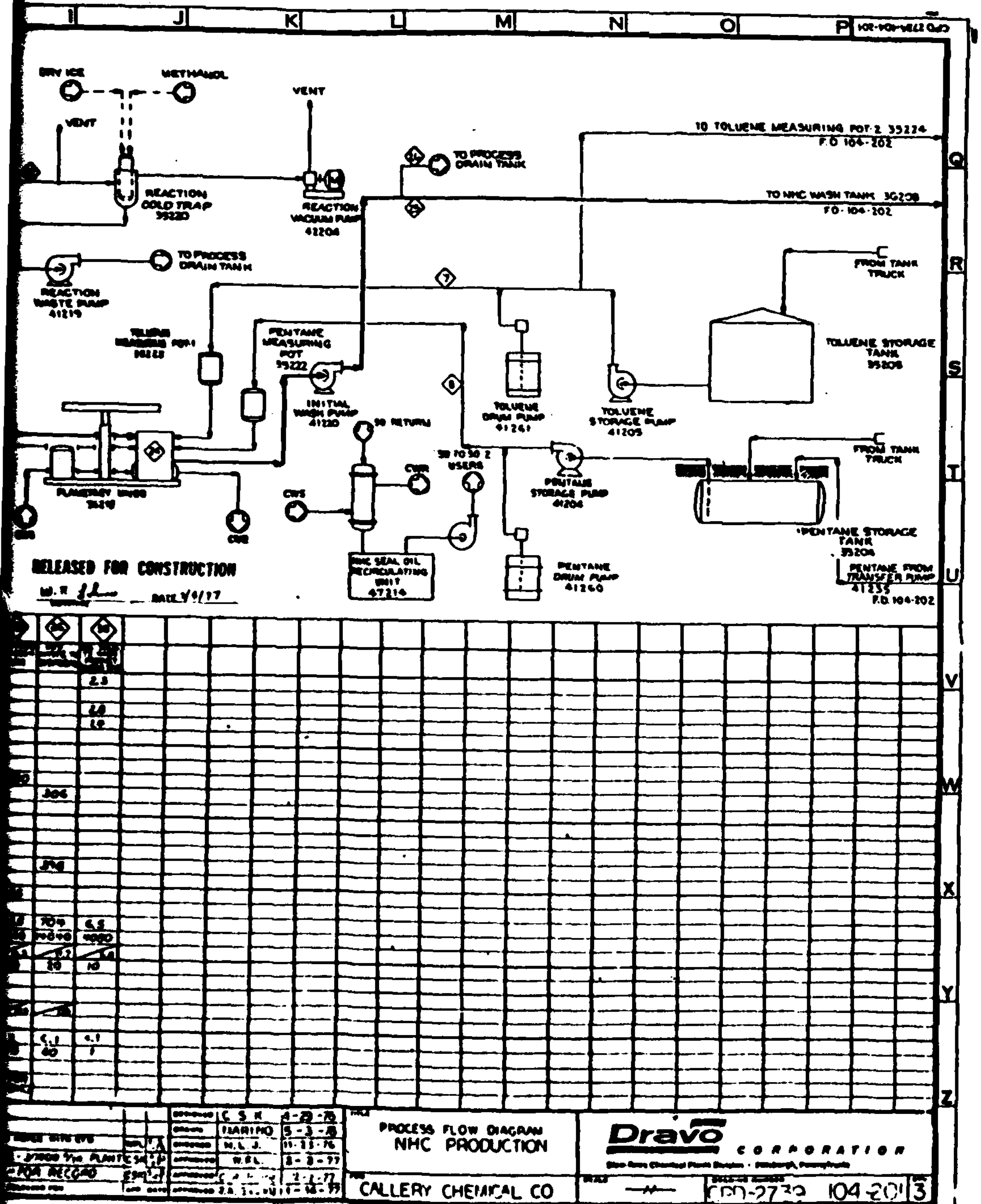
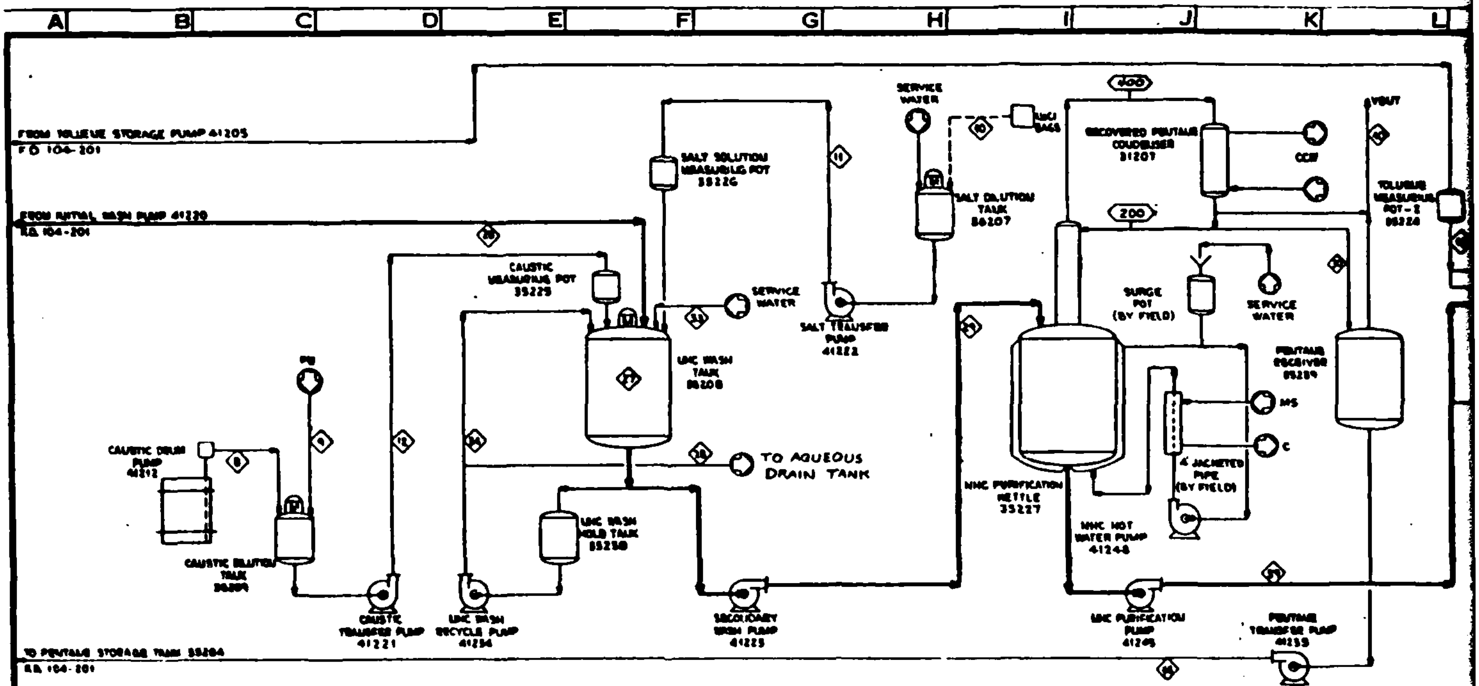


MATERIAL / STREAM No.	1	2	3	4	5	6	7	16	17	18	19	20	21	22	23	24	25	26	10
DESIGN FLOW RATE LB/DAY	[illegible] REC. PUMP	R-1 TO NHC REACTOR	R-3 TO R-3 REACTOR	1-OCTYNE TO NHC REACTOR	PENTANE TO PLANET MIXER	R-4 TO PLANET MIXER	TOLUENE WASH TO MIXER	TOTAL TO R-3 REACTOR	[illegible] R-3 REACTOR	W. PROD TO NHC REACTOR	TOTAL TO NHC REACTOR	OFFGAS FROM NHC REACTOR	COND. [illegible] VAPOR	NHC REACTION REC. VAPOR	NHC REAC. PRODUCT TO MIXER	MIX TO PLANET MIXER	[illegible] TO WASH TANK	[illegible] WASTE TO DISPOSAL	[illegible]
B10	101							103		101	101								2.3
NHC																			
R-1	121	143						129		129	267								2.8
R-2	60							62		62	62								1.9
R-3			125					125		125	125								
R-4						48										48			
1-OCTYNE				139							139								
PENTANE					1511											662	1000		
TOLUENE							306											306	
NaOH																			
NaCl																			
H2O																			
HYDROGEN									1.69			1.69		1.69					
WASTE LIQUID													420					398	
ORGANIC WASTE VAPORS												424		4.39					
REACTION PRODUCT STRM															263	263	428		
TOTAL	282	143	125	139	1511	48	306	414	1.69	412	694	426	420	6.08	263	973	1925	704	6.5
ACTUAL FLOW : LBS/HR	4080	1920	2100	1860	6240	2460	8640										6240	14640	4080
SPGR/LB PER GAL	/8.0	/5.41	/7	/6.2	/5.2	/8.2	/7.2	/8.0		/5.8	/5.38		/8.4		/8.7	/6	/5.2	/11.7	/5.8
GPM	10	5	5	5	20	5	20		-	20							20	20	10
MW				110			92		2										
SCFM/ACFM									.2/2										
PRESS PSIG/TEMP °F		10/AMB	/AMB	5/AMB	/AMB	/AMB	/AMB	61/320	61/90	/100	/100	314/266	/100	1/86	/113	8/113	/113	/113	
RANGE - PSIG/°F								[illegible]	[illegible]										
HRS PER BATCH	<.1	<.1	<.1	<.1	.3	<.1	<.1	24	24	2	8	4	1	1	.1	1/mixer	.2	<.1	<.1
GAL PER BATCH	41.5	22.2	17.9	22.5	291	5.9	42.5	61	-	61	105		66		30.5	162	273	60	1
TURNDOWN																			
NOTES					[illegible]				0.15CFM							[illegible]			

REV	DESCRIPTION	BY	DATE
3	REV [illegible] TO AGREE WITH [illegible]	[illegible]	[illegible]
2	PARTIAL ISSUE - 3/1000 [illegible] PLANT	CSK	[illegible]
1	GENERAL - FOR RECORD	CSK	[illegible]

DESIGNED	C S K
DRAWN	HARING
CHECKED	H.L.J.
APPROVED	W.F.L.
APPROVED	[illegible]


DRY ICE
METHANOL
VENT
VENT
REACTION COLD TRAP
REACTION VACUUM PUMP
TO PROCESS DRAIN TANK
TO TOLUENE MEASURING POT 2 35224
F.D. 104-202
TO NHC WASH TANK 36208
F.D. 104-202
TO PROCESS DRAIN TANK
REACTION WASTE PUMP 41219
FROM TANK TRUCK
TOLUENE STORAGE TANK 35205
PENTANE MEASURING POT 35222
INITIAL WASH PUMP 41220
TOLUENE DRUM PUMP
TOLUENE STORAGE PUMP 41205
CWR
CWS
PENTANE STORAGE PUMP
FROM TANK TRUCK
PENTANE STORAGE TANK
NHC SEAL OIL RECIRCULATING UNIT
PENTANE DRUM PUMP 41260
PENTANE FROM TRANSFER PUMP
F.D. 104-202
RELEASED FOR CONSTRUCTION
PROCESS FLOW DIAGRAM
NHC PRODUCTION
CALLERY CHEMICAL CO
Dravo CORPORATION
CPD-2739 104-201 3



MATERIAL / STREAM No.	8	9	10	11	12	13	14	15	25	27
DESIGN FLOW RATE: LB/DAY	CAUSTIC TO DILUTION	H2O TO CAUSTIC DILUTION	SALT TO SALT DILUTION	SALT SOL. TO UNC WASH	DILUTED CAUSTIC TO UNC WASH	TOLUENE TO MEAS POT-2	[illegible] PENTANE [illegible]	UNC PRODUCT	[illegible] PRODUCT TO WASH TANK	WATER TO WASH TANK
[illegible]										
UNC								100		
P-1										
P-2										
P-3										
P-4										
1-OCTYNE										
PENTANE							1000		1000	1000
TOLUENE						79				
NaOH	45				45					23
NaCl			27	27						
H_2O	45	476		515	521					261
HYDROGEN										
WASTE LIQUID										
ORGANIC WASTE VAPORS										
REACTION PRODUCT STREAM									425	415
TOTAL	90	476	27	542	566	79	1079	100	1425	1709
ACTUAL FLOW: LB PER HR.	3840	19040		5400	5400	8640	6240		6240	
SPGR/LB PER GAL.	[illegible]	[illegible]		3.6	9	7.3	5.2	7.5	5.2	5.2
GPM	5	25	—	10	10	20	20		20	–
GPH		16	565			72	72	228		
SCFM/ACFM										
PRESS PSIA/TEMP °F	AMB	AMB		AMB	AMB	AMB	100	210	315	100
GAUGE-PSIG/°F										
HRS. PER BATCH	<.1	<.1					2		.3	~2
GAL. PER BATCH	71	57		63	63	11	192	13.3	273	329
TURNDOWN										
NOTES				IN 3 EQUAL STEPS	IN 3 EQUAL STEPS				[illegible] IN [illegible] BATCHES	CAUSTIC WASH

MATERIAL / STREAM No.	28	29	30	31	33	34	35	36	37	39	40
DESIGN FLOW RATE: LB/DAY	[illegible] TANK WASTE	WASH TANK PRODUCT	PENTANE DISTILLATE	[illegible] RECYCLE	WASH WATER	UNC WASH RECYCLE	UNC VAC DIST UNIT VAPOR	UNC VAC DIST UNIT RESIDUE	DISTILLATE WASTE	UNC TO VACUUM DIST. UNIT	WASTE FROM UNC PUR KETTLE
[illegible]											
UNC				.3						100	
P-1											
P-2											
P-3											
P-4											
1-OCTYNE											
PENTANE		1000	1000	2.7					37	37	
TOLUENE								79			
NaOH	45										
NaCl	27										
H_2O	1896				810						
HYDROGEN											
WASTE LIQUID	91	113						43.5	37.1	81.6	
ORGANIC WASTE VAPORS							3.1				112.3
REACTION PRODUCT STREAM		220									
TOTAL	2009	1333	1000	3	810		81	121.5	74.1	220.6	112.3
ACTUAL FLOW: LB PER HR.		6600	200		10002			4320			
SPGR/LB PER GAL.		5.5		5.9	8.35			7.2			
GPM	20	20			20	10		10	20	10	
GPH			72		16						
SCFM/ACFM											
PRESS PSIA/TEMP °F	100	100	204				394	394		[illegible]	
GAUGE-PSIG/°F											
HRS. PER BATCH	.2	.2	5								
GAL. PER BATCH		242	192	.6	97			17			
TURNDOWN											
NOTES	1 BATCH PER DAY		[illegible] CUT		IN [illegible] EQUAL STEPS						

NO.	REV.	RELEASED FOR		DATE
3	[illegible] AND (3)91		WFL	
2	INITIAL ISSUE [illegible] PLANT		CSK	
1	GENERAL - FOR RECORD		CSK	

DESIGNED	C.S.K.	12-22-7[illegible]
DRAWN	M Finnegan	12-23-7[illegible]
CHECKED	C.S.K.	12-23-7[illegible]
APPROVED	W.F.L.	2-3-7[illegible]
APPROVED	[illegible]	1-1-7[illegible]
APPROVED	[illegible]	1-14-7[illegible]

PROC[illegible]

NH[illegible]

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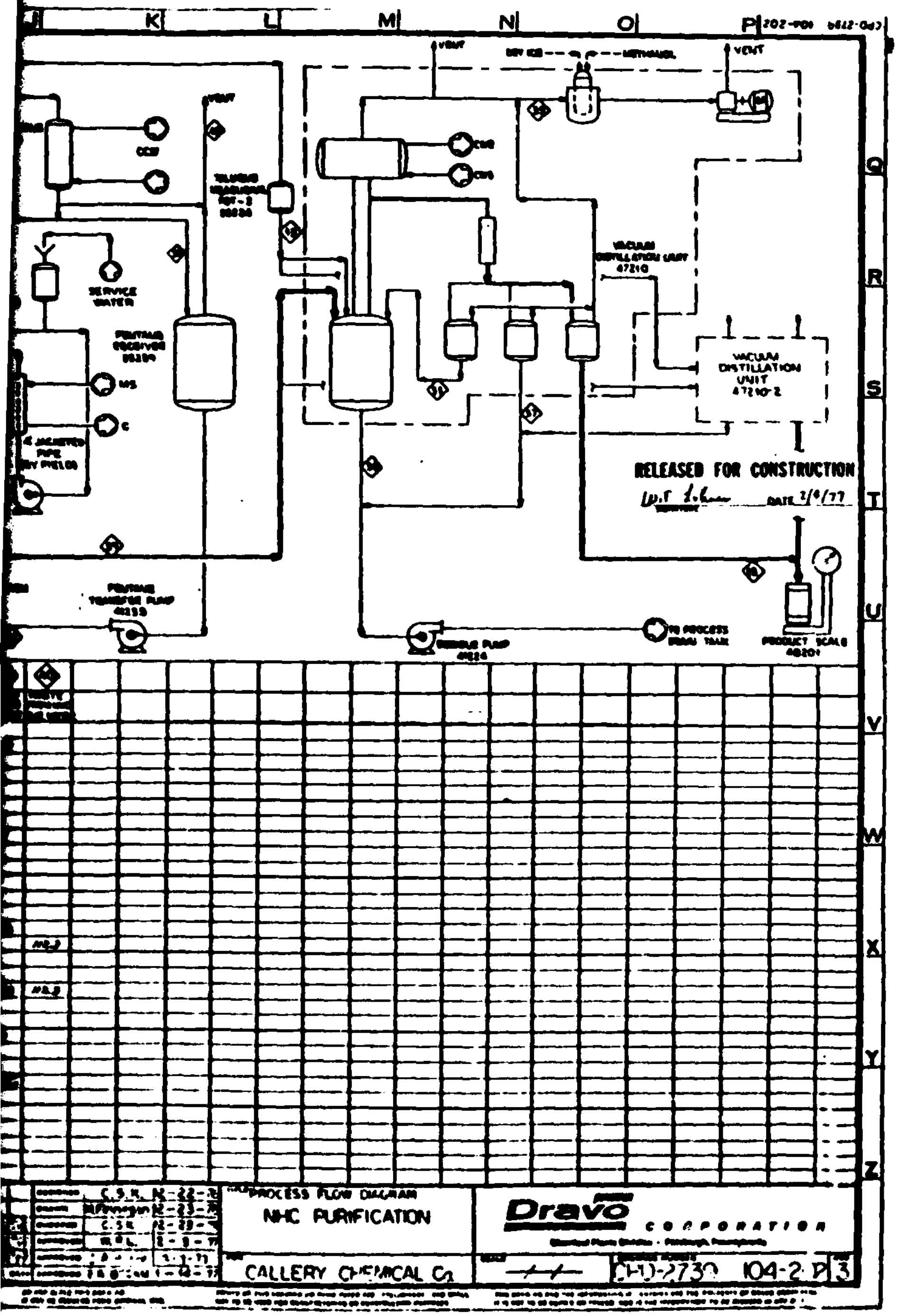
"D"



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METHANOL
SERVICE WATER
VACUUM DISTILLATION UNIT 47210
VACUUM DISTILLATION UNIT 47210-2
RELEASED FOR CONSTRUCTION
DATE 2/4/77
PRODUCT SCALE 48201
TO PROCESS
PROCESS FLOW DIAGRAM
NHC PURIFICATION
Dravo
CORPORATION
CALLERY CHEMICAL Co
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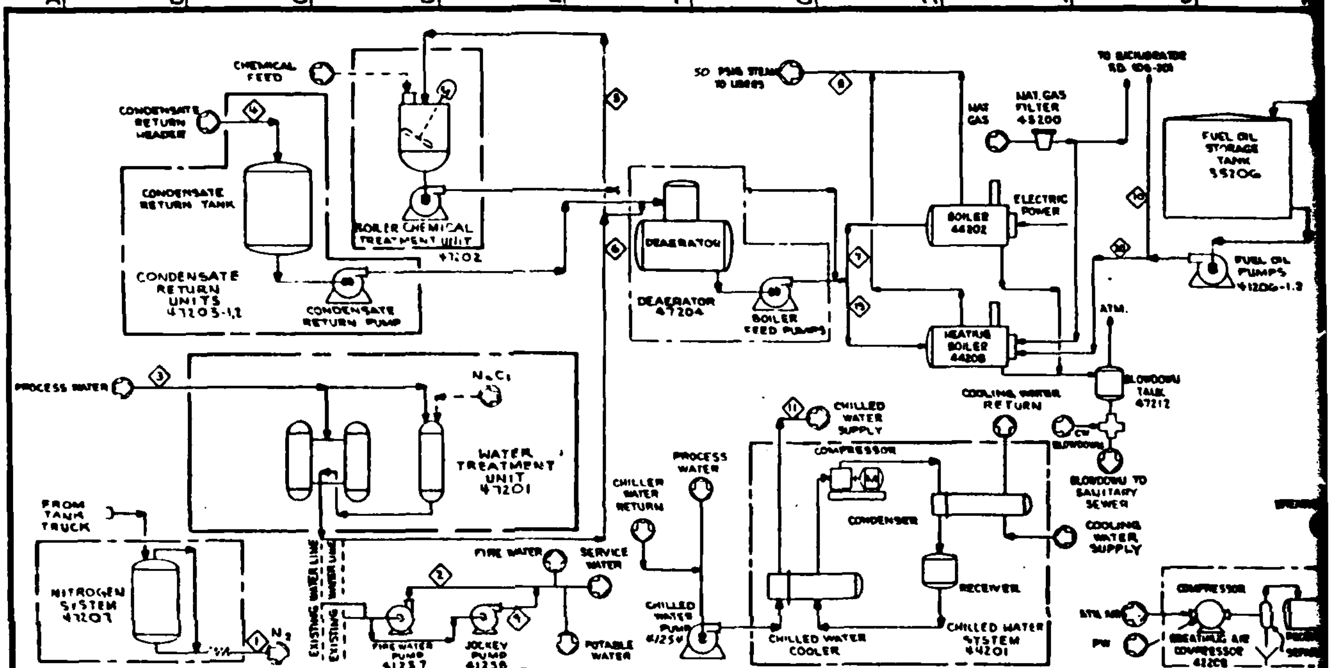
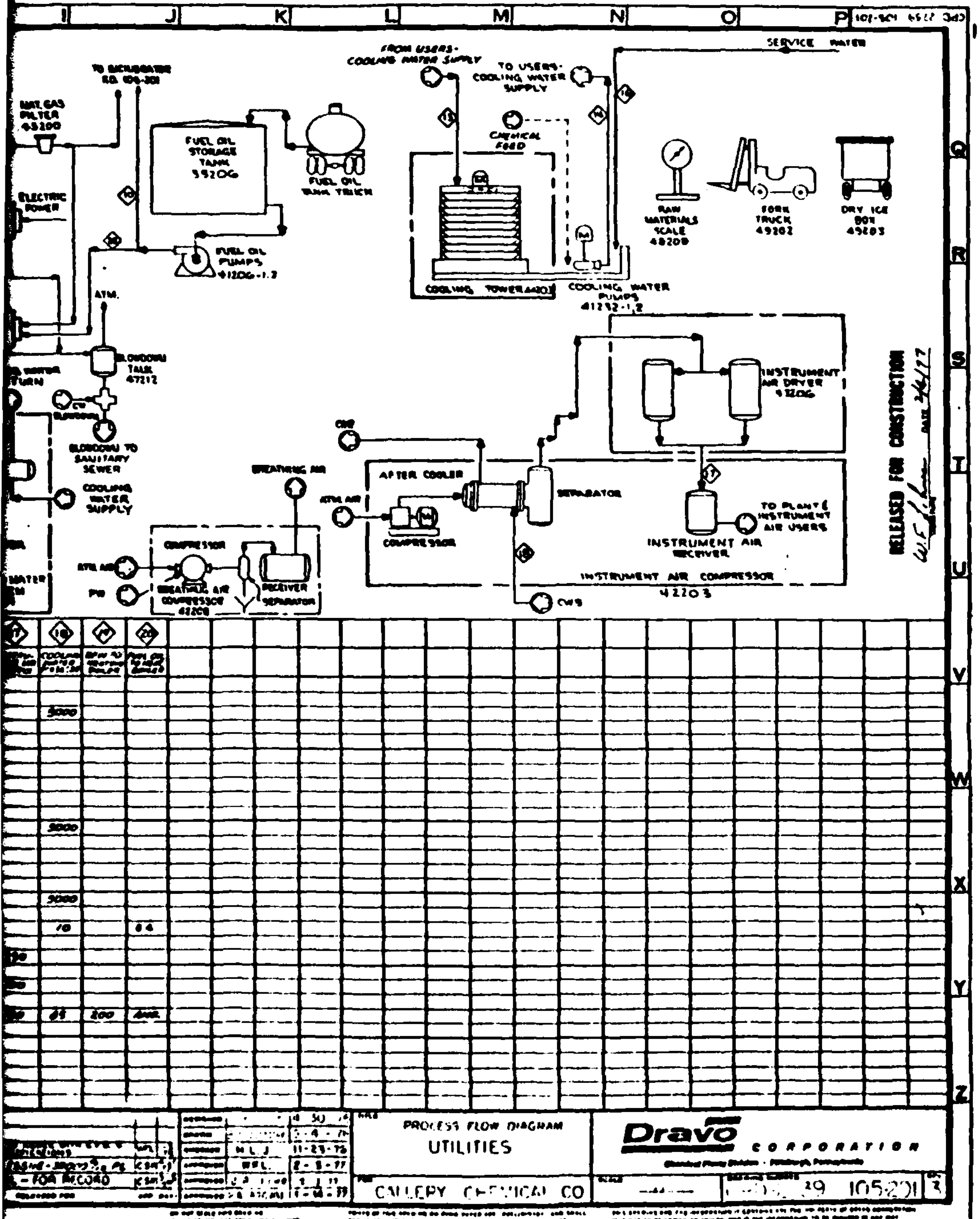
A B C D E F G H I J



MATERIAL / STREAM No.	1	2	3	4	5	6	7	8	9	10	11		13	14		16	17	18	19	20			
	INERT GAS	FIRE WATER	[illegible]	CONDENSATE RETURN	[illegible]	[illegible]	[illegible]	STEAM SUPPLY	POT. & SERVICE WATER	FUEL OIL TO HEATER	CHILLED WATER SUPPLY		COOLING WATER RETURN	COOLING WATER SUPPLY		COOLING WATER MAKE UP	INSTRUMENT AIR SUPPLY	COOLING WATER [illegible]	BFW TO HEATING BOILER	FUEL OIL TO HEAT. BOILER			
AIR																							
NITROGEN	219																						
H_2O			1000										150000	150000		2000		5000					
FREON																							
OIL																							
TOTAL	219		1000										150000	150000		2000		5000					
ACTUAL FLOW: LB PER HR.	219		1000	3011				3194			30000		150000	150000		2000		5000					
SP GR																							
GPM		1500	10 MAX		5 MAX	10 MAX	10 MAX		247 MAX	.13	60		300	300		[illegible]		10		0.4			
MW	28																						
SCFM	119 MAX																250						
ACFM																							
PRESSURE, PSIG	30	180						50									100						
PRESSURE RANGE, PSIG									110-125														
TEMPERATURE, °F	AMB.	AMB.	AMB	200	AMB	AMB	200	297	AMB	AMB	45		95	85		AMB	120	85	200	AMB.			
TEMPERATURE RANGE, °F																							
	[illegible]				INT																		
	[illegible]																						

REV.	DESCRIPTION	
3	[illegible] FINAL SPECIFICATIONS	WFL
2	INITIAL ISSUE - [illegible]	KSM
1	GENERAL - FOR RECORD	KSM

CHECKED M.L.J.
W.F.L.



SERVICE WATER
FROM USERS-
COOLING WATER SUPPLY
TO USERS-
COOLING WATER
SUPPLY
CHEMICAL
FEED
FUEL OIL
STORAGE
TANK
39206
FUEL OIL
TANK TRUCK
FUEL OIL
PUMPS
41206-1,2
ELECTRIC
POWER
ATM.
BLOWDOWN
TANK
47212
BLOWDOWN TO
SANITARY
SEWER
COOLING
WATER
SUPPLY
COOLING TOWER 44203
COOLING WATER
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41232-1,2
RAW
MATERIALS
SCALE
48209
FORK
TRUCK
49202
DRY ICE
BOX
49203
INSTRUMENT
AIR DRYER
43206
AFTER COOLER
SEPARATOR
COMPRESSOR
INSTRUMENT AIR
RECEIVER
TO PLANT &
INSTRUMENT
AIR USERS
INSTRUMENT AIR COMPRESSOR
42203
BREATHING AIR
ATM AIR
CWS
COMPRESSOR
BREATHING AIR
COMPRESSOR
RECEIVER
SEPARATOR
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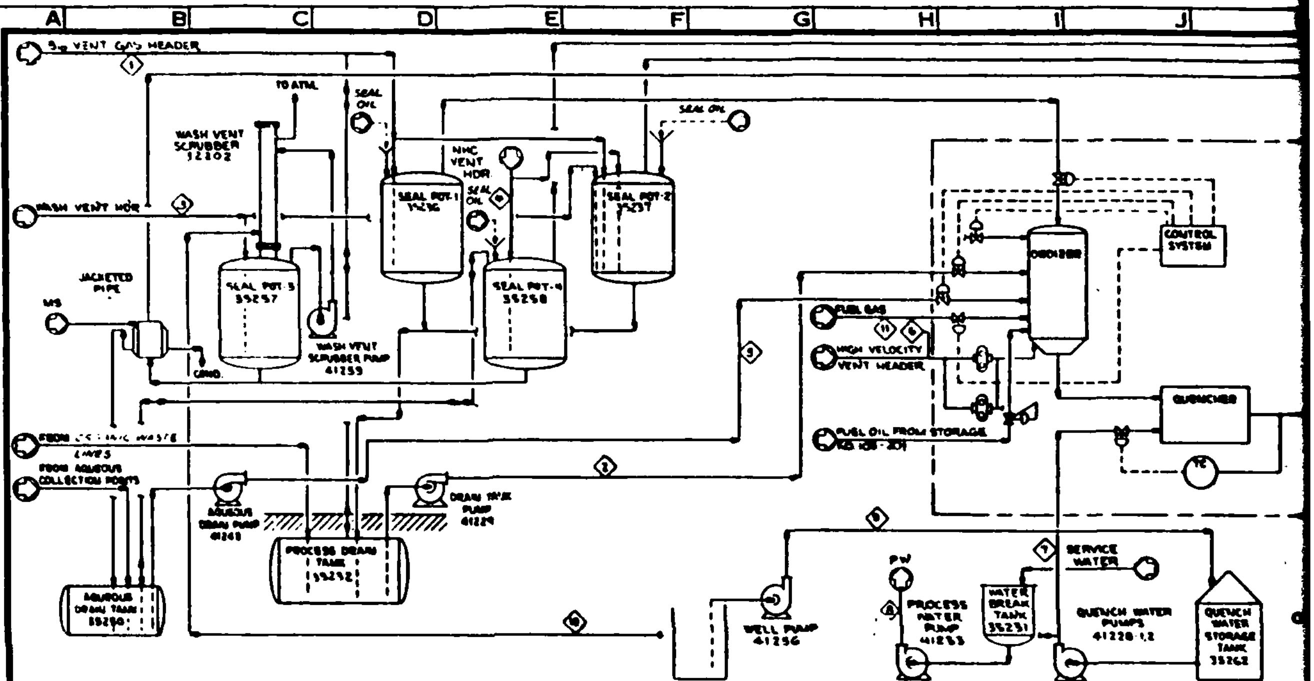
UTILITIES
Dravo
CORPORATION
CALLERY CHEMICAL CO
105201



MATERIAL / STREAM No.	1	2	3	4	5	6	7	8	9	10	11
DESIGN FLOW RATE: LB/HR	B-10 VENTS	ACID ... WASTES	WASH VENTS	NHC VENTS	ORGANIC WASTES	H.V VENTS	Q.W TO INCIN.	PROCESS WATER	WELL WATER	Q.W. TO HV SCRUB	FUEL GAS TO INCIN.
GASEOUS WASTES											
LIQUID WASTES											
AIR											
WATER									5000		
TOTAL											
ACTUAL FLOW LB PER HR							3500		5000	50	
SP. GR.											
GPM		0.4					7	20	10	.1	
MW											
SCFM	34		85 *	87		20					17
ACFM											
PRESSURE, PSIG	6" H₂O						100				
PRESSURE RANGE, PSIG											
TEMPERATURE, °F						AMB	AMB		60	AMB	AMB
TEMPERATURE RANGE, °F											
											ALT
											TO
											OIL

3 REV. PER ...
2 INITIAL ISSUE ...
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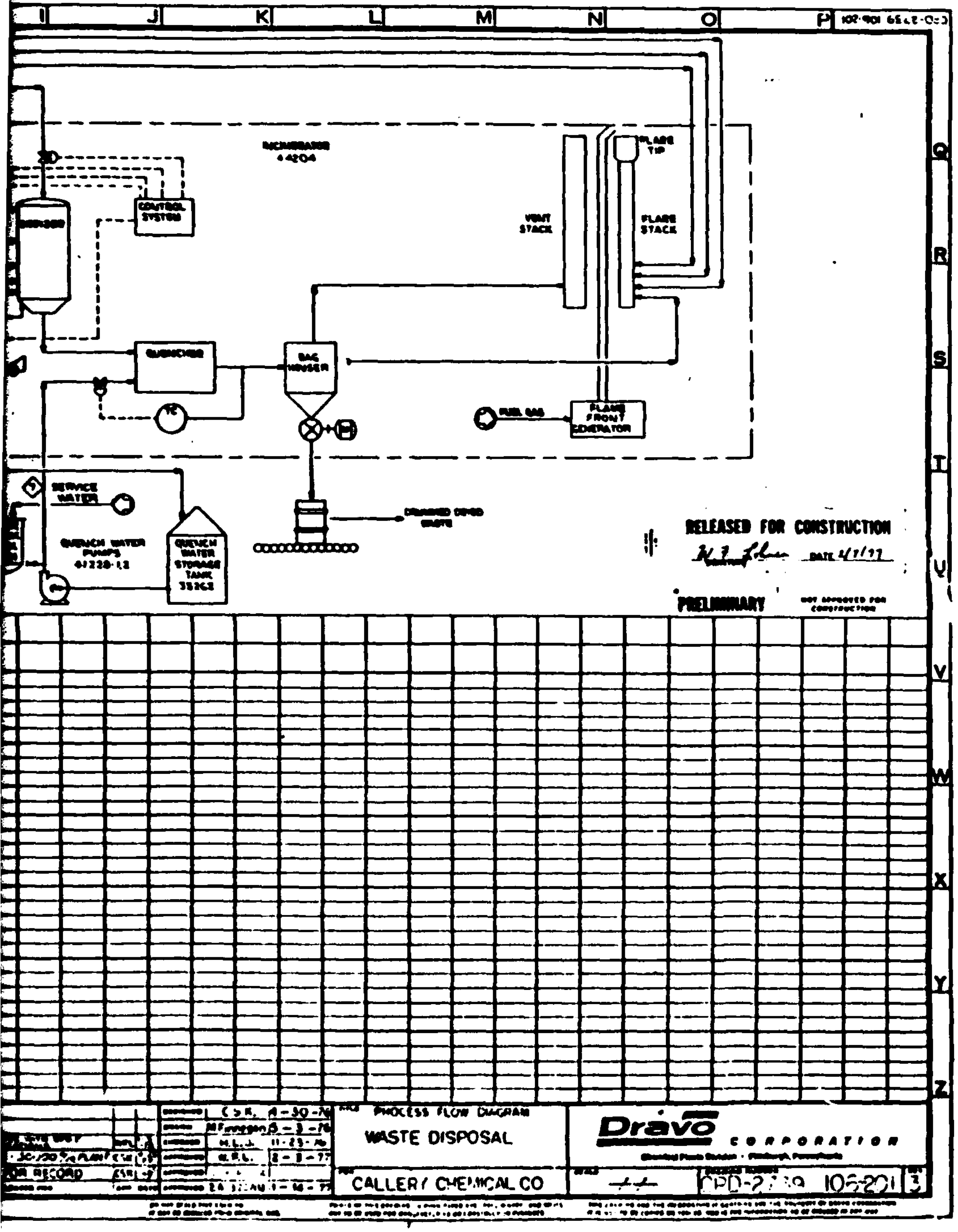

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CONTROL SYSTEM
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FLARE TIP
FLARE STACK
QUENCHER
BAG HOUSER
FUEL GAS
FLAME FRONT GENERATOR
SERVICE WATER
QUENCH WATER PUMPS 41228-1,2
QUENCH WATER STORAGE TANK
RELEASED FOR CONSTRUCTION
PRELIMINARY
NOT APPROVED FOR CONSTRUCTION
PROCESS FLOW DIAGRAM
WASTE DISPOSAL
Dravo CORPORATION
CALLERY CHEMICAL CO
FOR RECORD

2

DESIGN IMPLEMENTATION

General

According to the contract requirements, implementation of the NHC facility design will be accomplished by staged construction to allow (a) process demonstration, (b) low level production demonstration and (c) full scale production. The construction necessary for (a) and (b) will be accomplished concurrently and will include installation of only that equipment and necessary supporting facilities to demonstrate the process demonstration and to support low rate production. The final construction stage will include installation of additional equipment to expand production to the design rate of 30,000 lbs. NHC/yr.

Scheduled design implementation is described in the following paragraphs, listing that equipment and supporting facilities required for process and production demonstration and for expansion to full scale production.

Process and Production Demonstration

Equipment to be installed under the concurrent construction for process and production demonstration is listed in Table 2. Supporting facilities and operational modifications imposed by the limited construction are described below.

B10 Production - A total of four B10 reactors will be installed with the minimum structure for housing the reactors. Hexane recovery equipment will not be installed but structure for this part of the process will be erected. B10 collection and dissolving equipment to support the four reactors will be installed. Reactor wash solvents will be charged from drums. Deferred installation of hexane recovery equipment results in hexane usage on a once-through basis with wash solvent and B10 washed from the reactors being incinerated.

TABLE 2 - FACILITY REQUIREMENTS FOR PROCESS AND PRODUCTION DEMONSTRATION

Item No.	Description	Reqd. for Process Demo.	Added for Production Demo.
B10 AREA:			
35208	R-1 Measuring Pot	X	
35209	R-2 Measuring Pot	X	
35252 - 1, 2, 3	Product Receivers	X	
35252 - 4, 5, 6	Product Receivers	X	
35252 - 7, 8, 9	Product Receivers		X
35252 - 10, 11, 12	Product Receivers		X
35253	Filter Wash Tank	X	
35254	Hexane Charge Tank	X	
35255	Methanol-acetone Charge Tank	X	
35259	Dissolver Product Receiver	X	
36202	B10 Dissolver	X	
36215 - 1, 2	Reactor Loop, First Stage	X	
36215 - 3, 4	Reactor Loop, First Stage		X
36216 - 1, 2	Reactor Loop, Second Stage	X	
36216 - 3, 4	Reactor Loop, Second Stage		X
36217 - 1, 2	Reactor Loop, Third Stage	X	
36217 - 3, 4	Reactor Loop, Third Stage		X
39201	Methanol-acetone Agitator	X	
39202	B10 Dissolver Agitator	X	
41201	Hexane Drum Pump	X	
41207	R-1 Drum Pump	X	
41208	R-2 Drum Pump	X	
41215	Wash Discharge Pump	X	
41241	Hot Water Pump	X	
41250	Dissolver Receiver Pump	X	
45205	Dissolver Filter	X	
45206 - 1, 2	Product Vent Filters	X	
45206 - 3, 4	Product Vent Filters	X	
45206 - 5, 6	Product Vent Filters		X
45206 - 7, 8	Product Vent Filters		X
47203	Condensate Return Unit	X	
47208	Product Scale	X	
49201	Hand Truck	X	
43001	Hoist	X	
43002	Hopper Dumper	X	
50201	Purge Blower	X	

TABLE 2 - FACILITY REQUIREMENTS FOR PROCESS AND PRODUCTION DEMONSTRATION
(continued)

Item No.	Description	Reqd. for Process Demo.	Added for Production Demo.
NHC AREA:			
31206	NHC Reactor Condenser		X
31207	Pentane Condenser		X
32201	Pentane Purification Tower		X
35216	R-3 Measuring Pot		X
35217	R-1 Measuring Pot		X
35218	Octyne Measuring Pot		X
35219	Reaction Waste Receiver		X
35220	Reaction Cold Trap		X
35221	R-4 Measuring Pot		X
35222	Pentane Measuring Pot		X
35223	Toluene Measuring Pot		X
35224	Toluene Measuring Pot		X
35225	Caustic Measuring Pot		X
35226	Salt Solution Measuring Pot		X
35227	NHC Purification Kettle		X
35238	NHC Wash Hold Tank		X
35239	Pentane Receiver		X
36206	NHC Reactor		X
36207	Salt Dilution Tank		X
36208	NHC Wash Tank		X
36209	Caustic Dilution Tank		X
36210	Dissolver Surge Tank		X
39206	NHC Reactor Agitator		X
39207	Salt Dilution Agitator		X
39208	NHC Wash Agitator		X
39209	Caustic Dilution Agitator		X
39210	Dissolver Surge Agitator		X
41207	R-1 Drum Pump		X
41209	R-3 Drum Pump		X
41210	R-4 Drum Pump		X
41211	Octyne Drum Pump		X
41212	Caustic Drum Pump		X
41219	Reactor Waste Pump		X
41220	Initial Wash Pump		X
41221	Caustic Transfer Pump		X
41222	Salt Transfer Pump		X
41223	Secondary Wash Pump		X
41224	Residue Pump		X
41225	Product Pump		X

TABLE 2 - FACILITY REQUIREMENTS FOR PROCESS AND PRODUCTION DEMONSTRATION
(continued)

Item No.	Description	Reqd. for Process Demo.	Added for Production Demo.
41234	NHC Wash Recycle Pump		^
41235	Pentane Transfer Pump		X
41236	Forecut Pump		X
41245	NHC Purification Pump		X
41246	Filter Wash Pump		X
42204	Reaction Vaccum Pump		X
45202	Planetary Mixer		X
47203	Condensate Return Unit		X
47210	NHC Vacuum Distillation Unit		X
48201	Product Scale		X
UTILITY AREA:			
35231	Water Break Tank	X	
41227	Blowdown Pump	X	
42203	Instrument Air Compressor	X	
42208	Breathing Air Compressor	X	
44202 A	Process Boiler	X	
44202 C	Blowdown Tank	X	
47201	Water Treatment Unit	X	
47202	Boiler Treatment Unit	X	
47204	Deaerator	X	
47206	Instrument Air Dryer	X	
INCINERATOR:			
35236	Seal Pot #1	X	
35237	Seal Pot #2	X	
35257	Seal Pot #3	X	
35258	Seal Pot #4	X	
41228 - 1, 2	Quench Water Pumps	X	
41229	Drain Tank Pump	X	
41230	Incinerator Feed Pump	X	
41233	Process Water Pump	X	
41243	Aqueous Drain Pump	X	
41244	Aqueous Incinerator Pump	X	
44204	Incinerator Unit	X	

TABLE 2 - FACILITY REQUIREMENTS FOR PROCESS AND PRODUCTION DEMONSTRATION
(continued)

Item No.	Description	Reqd. for Process Demo.	Added for Production Demo.
TANK FARM AND YARD:			
35232	Process Drain Tank	X	
35250	Aqueous Drain Tank	X	
41232 - 1, 2	Cooling Tower Pumps	X	
44203	Cooling Tower	X	
47207	Nitrogen System	X*	
DRUM STORAGE:			
48209	Scale	X	
49201A	Fork Truck Drum Attachment	X	
49201	Fork Truck	X*	

*Leased Items

NHC Production - The complete NHC building structure will be constructed but several equipment items are deferred for installation under full scale expansion. Installation of the R-3 reactor is deferred with both the R-3 reaction and the NHC reaction being accomplished in the NHC reactor. The B10 dissolved in R-1 and R-2 will be transferred from the dissolver surge tank. The B10 solution is then metered to the NHC reactor with R-3. After completion of the R-3 reaction, the R-3 reaction mass is removed and held in the NHC reactor feed pot. After addition of R-1 and octyne to the NHC reactor, the R-3 reaction mass is slowly added while bringing the mixture to reflux temperature.

After completion of the NHC reaction, further processing steps and equipment are those for full scale operation through the initial NHC purification. Pentane stripping and recovery equipment is installed but will be operated at reduced recovery efficiency with condenser cooling by cooling water rather than chilled water (chilled water system deferred to full scale expansion). Final purification will be accomplished in only one vacuum distillation unit with installation of the second vacuum distillation unit deferred to full scale expansion.

Utilities Area - An electric process boiler will be installed with deaerator, chemical treatment unit and blowdown separator. The breathing air and instrument air compressor and dryer will be installed. The building structure will be built to house all of the equipment necessary for full scale operation. Equipment installation deferred to full scale expansion includes the building heat boiler and the chilled water system.

Tank Farm and Yard - None of the bulk storage tanks will be installed, with all materials being received and stored in drums. The only pad to be installed will be for the leased nitrogen system. Pipe racks will be sized and located for full scale production but piping installation will be only that required for the low level production equipment. The cooling tower and pumps will be installed.

Drum Storage - Only the foundations and floor slab of the drum storage building will be installed. Drums will be stored on the slab under tarpaulin cover. The fork truck for handling materials will be rented, but the drum handling adapter will be purchased.

Change House - The change house will be deferred until full scale expansion. Temporary facilities for personnel will be provided by a leased change trailer fitted with extra lockers for clothing.

Site Preparation - The entire site will be prepared, including all roads and underground services.

Incineration System - The full scale incineration system will be installed, including seal pots, waste tanks and feed pumps.

Full Scale Expansion

In the previous section, equipment and facilities necessary to conduct the process and production demonstrations and to support low level NHC production were identified. Under full scale expansion, the additional equipment and supporting facilities to expand the plant to full 30,000 lbs. NHC/yr. will be installed. This additional equipment is listed in Table 3.

Full scale installation of equipment within the B10 and NHC process areas will require a complete operational shutdown of approximately four months. Process areas and equipment used for demonstration and initial low level production will be cleaned, purged and tested for absence of fire or toxicity hazard prior to initiation of expansion construction work.

TABLE 3 - FACILITY REQUIREMENTS FOR FULL SCALE EXPANSION

ITEM NO.	DESCRIPTION
B_{10} AREA	
31205	Hexane Condenser
35212	R-1 Measuring Pot
35213	R-2 Measuring Pot
35214	Hexane Recovery Receiver
35215	Wash System Cold Trap
35241	Hexane Hold Tank
35252 - 13 through 36	Product Receivers
35253	Filter Wash Tank
35260	Wash System Receiver
36201	Methanol-Acetone Tank
36204	Wash System Kettle
36215 - 5 through 12	Reactor Loop, First Stage
36216 - 5 through 12	Reactor Loop, Second Stage
36217 - 5 through 12	Reactor Loop, Third Stage
39204	Wash System Kettle Agitator
41213	Methanol-Acetone Pump
41217	Hexane Recovery Pump
41237	Hexane Transfer Pump
41215 - 2	Wash Discharge Pump
41253 - 1	Hexane Wash Discharge Pump
41253 - 2	Hexane Wash Discharge Pump
42201	Borane Polymer Filter
42206	Spare Vacuum Pump
45201	Borane Polymer Filter
45206 - 9 through 24	Product Vent Filters
41246	Filter Wash Pump
41251	Wash Receiver Pump
NHC AREA	
36205	R-3 Reactor
36212	Wash Product Surge Tank
39205	R-3 Reactor Agitator
39212	Wash Product Surge Tank Agitator
41218	R-3 Reactor Pump
35224	Toluene Measuring Pot
41224	Residue Pump
41225	Product Pump
41236	Forecut Pump
47210 - 2	NHC Vacuum Distillation Unit
35207	NHC Reactor Feed Pot

TABLE 3 - FACILITY REQUIREMENTS FOR FULL SCALE EXPANSION (continued)

ITEM NO.	DESCRIPTION
UTILITY AREA	
44201	Chilled Water System
44208	Heating Boiler
35261	Chilled Water Expansion Tank
41254	Chilled Water Pump
TANK FARM AND YARD	
35202	Methanol Storage Tank
35203	Acetone Storage Tank
35204	Pentane Storage Tank
35205	Toluene Storage Tank
35206	Fuel Oil Storage Tank
41202	Methanol Storage Pump
41203	Acetone Storage Pump
41204	Pentane Storage Pump
41205	Toluene Storage Pump
41206 - 1, 2	Fuel Oil Storage Pump
47207	Nitrogen System
Drum Storage	
49201	Fork Truck

HAZARD ANALYSIS

General

At the onset of the design effort, review of the potential safety hazards presented by the various materials being processed and process conditions was made to provide criteria and general requirements in terms of the following basic areas:

1. Toxic hazard to personnel
2. Process hazards
3. Electrical classification
4. Fire protection

As the design developed, the hazard analysis was updated and refined to provide input for such areas as building design requirements, building and equipment layouts, relief and vent sizing, safety equipment requirements and locations, sprinkler systems, and ventilation requirements.

Process design and building layouts were reviewed at several stages of the design by Factory Mutual Engineering Corporation to assure compliance with pertinent codes and industry standards.

Reference Documents

Occupational Safety and Health Standards,
Code of Federal Regulations,
Title 29, Chapter XVII

DOD Contractors' Manual for Ammunition,
Explosives and Related Materials,
DOD 4145.26M

DOD Construction Criteria Manual,
DOD 4270.1-M

National Fire Codes 1975,
National Fire Protection Association

National Electrical Code 1975,
NFPA 70-1975,
National Fire Protection Association

Fire Hazard Properties of Flammable Liquids, Gases, Volatile Solids 1969 NFPA 325-M, National Fire Protection Association

Fire Protection Guide on Hazardous Materials, 6th Ed., 1975, National Fire Protection Association

Registry of Toxic Effects of Chemical Substances, 1975; 1976, National Institutes of Occupational Safety and Health

"Damage-Limiting Construction", Loss Prevention Data, Construction 1-44, February 1968, Factory Mutual Engineering Corporation

Basic Considerations

The principal hazard characteristics of the process materials, summarized in Table 1, dictate a design which will protect personnel, property and the environment from potential toxic exposure and fire and explosion hazards. As previously discussed, process conditions and operations were selected so as to minimize these potential hazards.

Containment of toxic and/or flammable fluids and particulate matter must be of primary concern, dictating a requirement of flanged, welded construction with sealing and gasketing materials selected on the basis of extensive prior experience with these and other similar process materials. As the maximum allowable concentrations (8-hr time weighted averages) of the process materials are generally well below their lower explosive limits it is not permissible to use a higher electrical hazard classification in lieu of containment.

To provide adequate process area ventilation, both the B10 and NHC process areas are provided with both low and high level ventilation intakes and are provided with make-up air at a rate equivalent to from 5 to 10 air changes per hr. A separate high velocity vent system is required in the process areas to provide short-term protection against minor leaks and during solid B10 transfer operations. This high

TABLE 4: HAZARD CHARACTERISTICS OF PROCESS MATERIALS

Substance	Vapor Density (air=1.0)	Flash Point ($0^{o}F$)	Ignition Temp. ($0^{o}F$)	Flammable Limits (Vol %) Lower	Upper	Max. Allowable Concentration (ppm)	HAZARD RATING * Health	Flammability	Reactivity
Diborane (B2)	0.96	gas	293	0.8	88	0.1	3	4	2
Decaborane (B10)	4.2	176	--	no data -	--	0.05 (skin)	3	2	1
Hydrogen	0.1	gas	752	4	75	--	0	4	0
Acetone	2.0	0	869	2.6	12.8	1000	1	3	0
Methanol	1.1	55	725	6	36.5	200	1	3	0
Pentane	2.5	-56	500	1.4	8	1000	1	4	0
Hexane	3.0	- 7	437	1.1	7.5	500	1	3	0
Toluene	3.1	40	896	1.2	7.1	200	2	3	0
Butyl Ether (R-1)	4.5	77	382	1.5	7.6	--	2	3	0
Dioxane (R-2)	3.0	54	356	2	22	100 (skin)	2	3	1
Butyl Sulfide (R-3)	5.0	--	---	no data	--	--	2 (Est'd)	2 (Est'd)	1 (Est'd)
Pyridine (R-4)	2.7	68	900	1.8	12.4	5	2	3	0
1-Octyne	--	--	---	no data	--	--			
NHC	--	Generally classified as non-volatile, non-combustible and non-toxic							

*See Table 4: - continuation, Explanation of Hazard Ratings

TABLE 4: EXPLANATION OF HAZARD RATINGS (NFPA) (cont.)

Health

4	Materials which in very short exposure could cause death or major residual injury even though prompt medical treatment were given
3	Materials which on short exposure could cause serious temporary or residual injury even though prompt medical treatment were given
2	Materials which on intense or continued exposure could cause temporary incapacitation or possible residual injury unless prompt medical treatment is given
1	Materials which on exposure would cause irritation but only minor residual injury even if no treatment is given
0	Materials which on exposure under fire conditions would offer no hazard beyond that of ordinary combustible material

Flammability

4	Materials which will rapidly or completely vaporize at atmospheric pressure and normal ambient temperature, or which are readily dispersed in air and which will burn readily
3	Liquids and solids that can be ignited under almost all ambient temperature conditions
2	Materials that must be moderately heated or exposed to relatively high ambient temperatures before ignition can occur
1	Materials that must be pre-heated before ignition can occur
0	Materials that will not burn

Reactivity

4	Materials which in themselves are readily capable of detonation or of explosive decomposition or reaction at normal temperatures and pressures
3	Materials which in themselves are capable of detonation or explosive reaction but require a strong initiating source or which must be heated under confinement before initiation or which react explosively with water

TABLE 4: EXPLANATION OF HAZARD RATINGS (NFPA) continued

2	Materials which in themselves are normally unstable and readily undergo violent chemical change but do not detonate. Also materials which may react violently with water or which may form potentially explosive mixtures with water.
1	Materials which in themselves are normally stable, but which can become unstable at elevated temperatures and pressures or which may react with water with some release of energy but not violently
0	Materials which in themselves are normally stable even under fire exposure conditions, and which are not reactive with water

velocity vent system is routed through the incineration system for oxidative destruction of any air contaminants.

A breathing air system must be provided in the process areas for use as a preventive measure whenever the process equipment is to be opened (after purging), for protection while correcting minor leaks and for possible emergencies. Hose couplings used for this system must be unique. Air supply to the breathing air compressor must be obtained from a source removed from any potential contamination.

All process equipment will be equipped with dry nitrogen supply for padding and purging. Primary nitrogen supply is from a liquid nitrogen system with a back-up emergency cylinder bank supply system.

Specific concern regarding B2 (and B2-hydrogen mixtures) prompted review of available data on flammability and potential explosion hazard. This review indicated that B2 presents no significantly different hazards with regard to potential fire and explosion than that posed by the other highly volatile and flammable materials being handled. In terms of hazard probability, the quantities of B2 being handled are much less than those of the other hazardous materials and thus the probable hazards presented by B2 are relatively small. Figure 16 shows typical average inventories of toxic and flammable materials in each structural bay of the main process buildings, B10 and NHC.

Contrary to much widespread opinion, various investigators have demonstrated that under ambient temperature conditions mixtures of B2 with dry air or oxygen are not spontaneously flammable. This fact has been exploited in the published studies of diborane-air and diborane-oxygen explosions.

150 C6	40 R1 - R2 200 MEOH 100 B10	0.8B2 45 B10	0.8 B2 45 B10	0.8 B2 45 B10
	50 MEOH-AC 50 C6	50 C6 or MEOH 0.4 B2 22 B10	0.8 B2 45 B10	0.8B2 45 B10

B10 - AREA 30

	300 C5	300 C5 50 TOL	200 B10 60 R1 15 R2 40 R3 25-Octyne
	300 C5	30 TOL	

NHC - AREA 40

LEGEND:

B2 - Diborane
B10 - Decaborane
C5 - Pentane
C6 - Hexane
R1 - Butyl Ether
R2 - Dioxane
R3 - Butyl Sulfide
MEOH - Methanol
AC - Acetone
TOL - Toluene

FIGURE 16: TYPICAL FULL SCALE OPERATING INVENTORIES OF FLAMMABLE ORGANICS (IN GALS.) AND TOXIC BORANES (IN LBS.)

Diborane-air mixtures are flammable over rather wide composition limits, with some discrepancies in the reported values of the upper limit. Most recent data available from NFPA give the limits as 0.8 to 88 volume percent. Martin, Kydd and Browne (1962)[1] investigated the spark initiated detonation of B_2-air mixtures at ambient temperatures and various pressures from 20 mm Hg to near 900 mm Hg. Table 5 summarizes the results of detonation velocity measurements the range from 2 to 27 volume percent (detonable limits are narrower than the flammable limits). For comparison, Tables 6 and 7, taken from Lewis and Von Elbe (1951)[2], show detonation velocities and detonable limits for H_2, CO and volatile organics with air or oxygen. These data show detonation velocities of B_2-air mixtures to be comparable to those of methane (or natural gas) - air mixtures.

Since theoretical pressure impulse or blast effects of explosion are directly related to detonation velocities, these data show that B_2-air mixtures have explosion hazards comparable to those of natural gas or volatile solvent vapor-air mixtures. In this regard it is informative that some of the reported experimental detonation studies were conducted in Pyrex pipe with no rupture of the pipe under normal detonation ignition conditions.

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1. Martin, F. J., P. H. Kydd and W. G. Browne, "Condensation of Products in Diborane - Air Detonations", Eighth Symposium on Combustion, Combustion Institute, Williams and Wilkins Co., 1962.
2. Lewis, B. and G. von Elbe, Combustion, Flames and Explosions of Gases, Academic Press, 1951

TABLE 5 SUMMARY OF DATA, DIBORANE-AIR SYSTEM

Run No.	B_2H_6	Equiv. Ratio[a]	Init. Press.	Init. Temp.	Observed Detonation Velocity,[b] D			Coef. of Var.[c]		Calc. Det. Vel.[d]
					3.175 cm tube	7.62 cm tube	Extrap. to infinite diam.	Over 15-cm intervals	Over 10-cm intervals	
	Mol %		*cm of Hg*	°C		*m/sec*				*m/sec*
6/10-1	2.00	0.292	76.1	30.0	1372	1377	1381 ± 7	0.61	0.88	1382
6/15-1	2.32 *b*[e]	0.340	76.1	21.0	1433	1418	1411 ± 5	1.10	0.75	
6/17-1	2.32 *b*	0.340	75.4	21.0	1424 *ls*[e]	1432 *ls*	1438 ± 5	1.10	1.32	
6/18-1	2.52 *b*	0.370	75.4	21.0	1459 *ls*	1467 *ls*	1473 ± 5	1.56	2.39	
6/24-1	2.52 *b*	0.370	89.6	26.0	1452			0.86		
4/28-1	2.64	0.388	76.3	24.0	1614 *ls*	1636 *ls*	1652 ± 10[f]	3.82	6.32	1509
4/29-1	2.64	0.388	35.8	24.0	1467	1484	1496	1.13	2.07	
6/30-1	2.64	0.388	76.6	30.0	1480 *ls*	1496 *ls*	1507 ± 5	0.73	1.60	1509
7/2-1	2.64	0.388	86.7	24.0	1487 *ls*			1.29		
6/26-1	2.74	0.402	75.9	24.0	1496 *ls*	1513 *ls*	1525 ± 5	1.47	1.77	
5/1-1	3.10 *b*	0.457	76.9	24.0	1563 *ls*	1576 *ls*	1585 ± 5	0.37	1.06	1589
5/5-1	3.10 *b*	0.457	76.1	24.0	1554 *ls*	1569 *ls*	1582 ± 5	0.58	0.84	
5/8-1	3.48	0.516	75.9	24.0	1630 *ls*	1637 *ls*	1642 ± 5	0.56	3.96[g]	1649
5/8-2	3.48	0.516	75.9	24.0	1629 *ls*	1637 *ls*	1643 ± 5	0.50	5.23[g]	
3/11-1	4.02	0.598	76.2	24.0	1687 *ls*	1708 *ls*	1723 ± 5	0.41	1.06	1724
3/12-1	4.02	0.598	76.1	24.0	1686	1708	1724 ± 5	0.77	1.90	
3/2-1	5.02	0.755	74.7	24.0	1822	1828	1832 ± 5	0.08	0.51	1838
3/3-1	5.02	0.755	75.2	24.0	1820	1827	1832 ± 5	0.26	0.91	
12/19-1	5.90	0.896	75.2	24.0	1890	1896	1900 ± 5	0.18	0.81	1914
12/19-2	5.90	0.896	74.8	24.0	1892	1897	1900 ± 5	0.19	0.64	
12/22-1	5.90	0.896	47.3	24.0	1876 *a*[h]	1884 *a*	1890			
12/23-1	5.90	0.896	22.7	24.0	1825	1853	1873	0.33	0.92	
12/23-2	5.90	0.896	10.0	24.0	1774	1810	1836	0.52	0.98	
12/29-1	5.90	0.896	3.6	24.0	1719	1774	1814	0.44	0.62	
12/5-2	6.53	0.998	74.0	24.0	1937	1940	1942 ± 5	0.25	0.80	1958
12/5-1	6.53	0.998	74.2	24.0	1936			0.64		
12/10-1	6.53	0.998	45.7	24.0	1916	1926	1933	0.37		
12/10-2	6.53	0.998	24.3	24.0	1888	1897 *a*	1903			
12/11-1	6.53	0.998	12.8	24.0	1837 *a*	1867 *a*	1880			
12/11-2	6.53	0.998	5.6	24.0	1802	1835	1859	0.33	0.77	
12/12-1	6.53	0.998	1.9	24.0	1675	1747	1802	0.46	0.65	
1/7-1	7.86	1.219	75.5	24.0	1988	1991	1993 ± 4	0.30	0.64	2000
1/8-1	7.86	1.219	75.6	24.0	1989	1991	1992 ± 4	0.25	0.43	
1/15-2	10.15	1.614	74.2	24.0	2024	2028	2031 ± 4	0.17	0.63	2040
1/16-1	10.15	1.614	73.5	24.0	2025	2026	2027 ± 4	0.39	0.58	
1/19-1	10.15	1.614	10.0	24.0	1947	1967 *a*	1981	0.11		
1/19-2	10.15	1.614	5.3	24.0	1898	1928	1950	0.24	2.06[g]	
1/12-1	12.31	2.006	76.5	24.0	2047	2040	2041 ± 3	0.36	0.37	2032
1/12-2	12.31	2.006	76.0	24.0	2038	2041	2043 ± 3	0.27	0.65	
1/13-1	12.31	2.006	38.1	24.0	2007	2021	2031			
1/14-1	12.31	2.006	12.9	24.0	1931	1975	2006	0.27	0.99	
1/15-1	12.31	2.006	2.0	24.0	1795	1887	1953	0.71	0.49	
1/22-1	15.1	2.55	74.7	24.0	2027 *ls*	2011 *ls*	2050 ± 10	0.33	3.74	2016
1/23-1	15.1	2.55	76.1	24.0	2023	2037	2047 ± 10	0.42	1.22	
2/4-1	15.1	2.55	36.2	24.0	1974	1998	2015	0.44	0.68	
1/26-1	15.1	2.55	9.8	24.0	1955			0.28		
7/28-1	15.9 *b*	2.70	75.9	27.4	2027 *ls*	2022 *ls*	[i]	2.33	1.06	2008
7/29-1	15.9 *b*	2.70	75.9	31.0	2012 *ls*	2014 *ls*	2015	0.52	1.61	
7/31-1	15.9 *b*	2.70	38.6	24.0	1998	1991	[i]	1.53	1.34	
8/14-1	18.1	3.15	76.2	24.0	1989	1996	2001 ± 10	1.69	0.86	1969
8/17-1	18.1	3.15	38.1	24.0	1944	1946	1947	0.65	1.18	
8/19-1	18.1	3.15	≈20.0	26.0	1922	1930	1936	0.24	3.46	
8/20-1	22.2	4.07	75.8	33.0	1944	1945	1945 ± 10	1.21	2.37	1860
9/16-1	27.2	5.34	76.2	24.0	1902	1931	≈1952 + 5 − 25	1.61	0.85	

From Martin, Kydd and Browne (1962)

TABLE 6 Detonation velocities of various mixtures at room temperature and atmospheric pressure.

Mixture	Detonation velocity, m./sec.	Mixture	Detonation velocity, m./sec.
$2H_2 + O_2$	2821	$C_3H_8 + 3O_2$	2600
$2CO + O_2$	1264	$C_3H_8 + 6O_2$	2280
$CS_2 + 3O_2$	1800	$i\text{-}C_4H_{10} + 4O_2$	2613
$CH_4 + 2O_2$	2146	$i\text{-}C_4H_{10} + 8O_2$	2270
$CH_4 + 1.5O_2 + 2.5N_2$	1880	$C_5H_{12} + 8O_2$	2371
$C_2H_6 + 3.5O_2$	2363	$C_5H_{12} + 8O_2 + 24N_2$	1680
$C_2H_4 + 3O_2$	2209	$C_6H_6 + 7.5O_2$	2206
$C_2H_4 + 2O_2 + 8N_2$	1734	$C_6H_6 + 22.5O_2$	1658
$C_2H_2 + 1.5O_2$	2716	$C_2H_5OH + 3O_2$	2356
$C_2H_2 + 1.5O_2 + N_2$	2414	$C_2H_5OH + 3O_2 + 12N_2$	1690

TABLE 7 Limits of detonability.

Mixture	Lower limit Per cent fuel	Upper limit Per cent fuel
H_2-O_2	15	90
H_2-air	18.3	59
CO-O_2, moist	38	90
CO-O_2, well dried	—	83
(CO + H_2)-O_2	17.2	91
(CO + H_2)-air	19	59
NH_3-O_2	25.4	75
C_3H_8-O_2	3.2	37
i-C_4H_{10}-O_2	2.8	31
C_2H_2-O_2	3.5	92
C_2H_2-air	4.2	50
$C_4H_{10}O$(ether)-O_2	2.6	> 40
$C_4H_{10}O$-air	2.8	4.5

From Lewis and Von Elbe (1951)

Review of the referenced DOD Contractor's Manual for Ammunition, Explosives and Related Materials indicates that this Manual is not applicable to the NHC production facility since ammunition, explosives and related materials as defined by the Manual are not being handled.

Hazard characteristics and related requirements specific to individual areas of the NAC facility are treated in the following subsections.

Tank Farm (Area 11)

Principal hazard in this area is the danger of fire from flammable solvent vapors. Methanol and toluene have the greatest toxicity hazard with maximum allowable concentrations of 200 ppm each. Above ground tanks and transfer areas are diked to contain spillage. The area is exposed, with resultant natural ventilation and dispersion. Storage tanks are fitted with pressure relief valves and flame arrested vents (conservation and emergency vents).

Hazards are reduced by storage of pentane and acetone in underground tanks and use of correct fill piping to avoid static charge buildup.

Electrical classification is Class I, Group D and either Div. 1 or Div. 2 depending on distances from vents and elevation relative to grade.

Automatic fire protection is not required. Fire water is provided by a local hose take off.

Drum Storage (Area 12)

The drum storage building is used only for storage of sealed drums, with no pumping of flammable liquids taking place. Electrical classification is therefore non-hazardous.

Automatic sprinkler protection is required with ceiling mounted heads having 286^{o}F temperature setting.

Change House (Area 15)

This building is used only for plant personnel convenience (showering, clothes changing etc.) and has no process operations. Electrical classificatin is therefore non-hazardous. Automatic sprinkler protection is required if Class I roof decking is employed. As an alternative, Class II decking without automatic sprinklers would be allowable. Final determination will be made by cost trade-off analysis when sprinkler system costs have been determined.

B10 Production Building (Area 30)

The B10 building houses the B10 reactors, segregated into about two thirds of the building with six structural bay areas each housing two B10 reactors. The remaining process portion of the building houses the recovery/filtration operations associated with processing of the reactor wash solutions and dissolving of solid B10 reactor product.

Operations in the B10 building involve processing of diborane in the pyrolysis loops and the handling and transfer of solid B10 reactor product and thus the major potential borane toxicity hazards are confined to this one area.

Occupancy of the B10 building is defined as type D-1, extra hazardous, according to the Pennsylvania Fire and Panic Code. Although equipment must be mounted on several levels to permit adequate gravity flows and equipment access, a variance from the height and structural limitations of Type III construction, D-1 occupancy, has been granted by the Industrial Board allowing the building to be considered single story.

Based on consideration of the potential vapor (solvent, B_2 or hydrogen) explosion hazard, the building is designed with damage-limiting construction according to criteria of Factory Mutual Engineering Corp. The design thus incorporates pressure-relieving walls and and pressure-resistant roof, with a strength ratio between resistant and relieving of 5:1. Pressure-resistant wall construction is also employed to separate the operating areas and the motor control center and other non-operating spaces.

With the designed pressure-resistant roof, heating and ventilation equipment are supported from the roof structure, eliminating the need for extra equipment support structure.

The fire protection system for this building, based on recommendations of insurance underwriter review, includes auotmatic sprinkler protection, both at ceiling and beneath the equipment access grating. Sprinkler density will be 0.3 gpm with head spacing not to exceed 100 ft^2. Sprinkler head temperature settings are 286^{o}F at ceiling and 165^{o}F below the grating. All steel supporting process equipment having an operating volume of more than 100 gallons of flammable liquid will have a one hour fire protective coating.

Electrical classification within the process areas will be Class I, Group B, Division 2. Control room and non-process areas will be classified non-hazardous by positive pressure ventilation. Due to the low auto-ignition temperatures of materials handled in the B10 production area, the heated sections of the B10 reactor loops will be enclosed and purged with positive air pressure.

Analysis of equipment failure modes indicates fire exposure to be determining in sizing of relief vents and vent headers. Relief sizing calculations are given in Appendix D.

Special design consideration was given to the B_2 piping to the B10 reactors and to the transfer of collected solid B10 reactor product. The B_2 supply line is equipped with an emergency shut off valve remotely actuated from the control room. B_2 lines to the individual reactors are fitted with double block and bleed valves to prevent leakage during reactor washout operations. Due to potentially hazardous reaction of boron hydrides with halogenated compounds and especially carbon tetrachloride, no halogenated materials (except "Teflon") or solvents are permitted in the B10 process area.

To summarize the hazard reduction design procedures, the B10 area design will include the following:

Extensive nitrogen inerting capability
Emergency stop valve on B_2 supply
Low but positive process pressures
Separate vent headers for B_2 and wash solvent vapors
Extensive building air changes
High velocity vent system
Breathing air system
Sprinkler system
Localized structure fire proofing
Damage-limiting relief wall design
Air purging of hot reactor surfaces
Location of control room at grade
Strict policing of operating and maintenance procedures

<u>NHC Production Building (Area 40)</u>

The only significant difference between the potential hazards present in the NHC area and those described for the B10 area is that of borane vapor toxicity. Operations in the NHC area involve solutions of B10 and degraded open-cage borane structures which are potentially toxic on skin exposure or contact but do not have any significant toxic vapor hazard. The greatest vapor toxicity hazard is that presented by pyridine (R-4) with a 5 ppm MAC. In terms of potential fire and vapor explosion hazard, the types and quantities of volatile flammable solvents employed require damage-resistant construction similar to that required for the B10 area. Certain of the solvents and organic reactants have the added potential hazard of forming toxic products when heated to decomposition.

Electrical classification in the process areas is Class I, Group D,Div.2 (auto-ignition temperature limit of 500°F). Office and lab areas are classified non-hazardous by positive pressure ventilation.

Pentane, bacause of quantity and flammability (Class IA liquid), presents the most significant fire hazard. Other flammables are Class 1B liquids.

Analysis of possible failure modes of the various reaction steps indicates fire exposure of filled vessels as being determining in vent and relief sizing calculations. None of the reactions present a significant reaction runaway hazard, being at most only moderately exothermic. Relief and vent sizing calculations are given in Appendix D.

Fire protection system requirements are the same as those described for the B10 building; density of 0.3 gpm, 100 ft^2 spacing, 286°F ceiling heads and 165°F below grating heads.

In summary, hazards of NHC production operations are reduced by the following design and operating requirements:

- Extensive nitrogen inerting capability
- Vent headers for PSV's and rupture discs
- Extensive ventilating air changes
- High velocity vent system
- Breathing air system
- Automatic sprinkler system
- Localized structural fire proofing
- Damage-limiting construction
- Strict policing of careful operating and maintenance procedures

Utility Building (Area 50)

The only process hazards in this area are those of low pressure steam and fuel oil. No volatile solvents or toxic materials are handled. The heating boiler will have

code approved combustion safe guards; the process boiler is electrically heated. Automatic sprinkler protection is required only in the area of the firing head of the fuel fired boiler.

Incinerator (Area 60)

The incinerator is an unhoused structure with the major process hazards being those of flammable waste products within closed piping.

The area is generally classified as electrically non-hazardous with the following exceptions:

Class I, Group D, Div. 1 within any sumps, pits or trenches;

Class I, Group D, Div. 2 within three feet of pumps handling flammable liquids and up to 18 inches above grade within a horizontal distance of ten feet from such a pump.

Automatic sprinkler protection is required only for the seal pots and the firing head of the incinerator. Wet pipe system acceptable if adequately protected against freeze-up.

Yard Area

The yard area is essentially non-hazardous except in the immediate vicinity of the solvent and reactant drums located adjacent to the B10 and NHC buildings. These drums are equipped with air driven pumps to minimize hazards.

Fire hydrants with curb box control valves are located at strategic intervals along the 10 inch underground fire main. The underground main provides a combination fire and process water system with supply taps from the existing outlet lines from both water reservoirs. Existing requirements for maintaining reservoir reserve capacity assures adequate emergency fire water supply. A 1500 gpm Diesel driven fire pump, automatically activated at 100 psig,

is connected by suction to both 8 in. reservoir lines. Pump location is such as to provide positive head at minimum allowable reservoir elevation. An electrically driven jockey pump maintains the normal main pressure of 125 psig with sufficient capacity to meet process water usage.

The in-plant road is looped to provide access to all sides of the critical areas, the B10 and NHC buildings. Auxiliary fire service is provided by the Callery/MSA plant fire department.

ENVIRONMENTAL IMPACT ASSESSMENT

General

As soon as the site selection for the proposed NHC production facility was finalized, an Environmental Aspects Report (Contract Data Item Sequence A00E) was prepared and submitted. The findings of that report indicated that implementation of the proposed facility would not represent a major environmental action and would not require an Environmental Impact Statement.

Pertinent portions of the Environmental Aspects Report are presented in the following summary.

Summary of Environmental Aspects

The NHC production facility will be located adjacent to the Callery/MSA plant site in a predominantly rural setting. Major land usage within a ten mile radius is farming and light industrial operations. Nearby communities are; Callery boro (population ~450), about one mile south and Evans City (population ~2000), about 2 miles northwest of the plant site.

The immediate land area to be occupied by the production facility consists of 3-4 acres on a knoll relatively higher than the surrounding area. The site is currently not in productive use and is covered primarily by small second growth trees and scrub underbrush. The area is not sufficiently large to support any significant population of wild life.

The plant site is within the cognizance of Region V of the Pennsylvania Department of Environmental Resources but is not within any designated air basin. Ambient air quality standards, promulgated by the Commonwealth of Pennsylvania, Title 25, Part I, Subpart C, Article III, Chapter 131 are:

	Concentrations Averaged Over		
	1-Year	30-days	24-hours
Settled Particulate (total)	0.8 $mg/cm^2/mo$	1.5 $mg/cm^2/mo$	
Lead	-	5 ug/m^3	
Beryllium	-	0.01 ug/m^3	
Sulfates (as H_2SO_4)	-	10 ug/m^3	30 ug/m^3
Fluorides (total soluble as HF)	-	-	5 ug/m^3
Hydrogen Sulfide	-	-	0.005 ppm

The anticipated usage of the facility for production of NHC will have no significant adverse impact on the environment.

As designed, the NHC production facility will have a comprehensive waste collection and disposal system. All process wastes, both liquid and vapor, are routed through enclosed piping and vent headers to the incineration system. Separate vent headers for incompatible vapor streams are isolated by means of inert liquid seal pots and under normal operation are fed directly to the incinerator for destructive oxidation. In event of an accidental process vapor surge of high volume and rate, excess flow by passes the incinerator to an emergency flare system for destructive oxidation before venting to the atmosphere.

Process liquid streams are collected in separate organic and aqueous process drain tanks and subsequently metered to the incinerator combustion chamber. Major constituents of the process waste steams are combustible organics and water, which on thermal oxidation, produce innoucuous combustion products, CO_2 and H_2O vapor. Minor waste stream constituents which require subsequent incinerator combustion product controls include boron, sodium, sulfur and chlorine in various organic and inorganic forms. Oxidation of these minor constituents results in formation of oxides and salts which are separated from the incinerator off gas by direct water quench and subsequent solids collection. Innocuous combustion products and water are vented to the atmosphere while the separated dry solids are drummed for off site contract waste disposal in an approved solid waste disposal facility.

Sanitary wastes from the NHC facility will be routed through the existing Callery/MSA waste treatment facility. This is a relatively new facility which meets current and anticipated future effluent standards and guidelines.

Non-process solid wastes, primarily paper and wood rubbish, will be disposed off site by contract landfill service.

Solvent and raw material storage and transfer operations will be appropriately diked and contained to prevent escape of accidental spillage.

Storm water run off will be segregated and routed to outfalls designed to minimize erosion.

No significant noise generation sources are employed in the proposed facility.

Alternatives to the proposed action are limited. The plant product, NHC, is employed in a weapons system vital to national defense. Site location is constrained by shipping limitations on the primary raw material, diborane. Alternative sites possible within this constraint have been evaluated and, in terms of potential environmental impact, the proposed site provides the least adverse impact.

Potential process changes that could lessen adverse environmental impact are limited by technology. Design tradeoffs have minimized the relatively small irreversible commitments of raw materials, solvents and energy. The incinerator design utilizes waste combustion energy to evaporate water from the process wastes and provides a minimum volume of dry solid wastes for disposal.

TABLE 8 - NHC FACILITY PREDICTED SYSTEMS AVAILABILITY SUMMARY

B-10 Area		
.995	B-10 Reactor Loops *	.90
	Dissolver-Filter	.995
	Hexane Recovery	1.00
NHC Area		
.9243	R-3 Reactor	.995
	NHC Reactor	.98
	Planetary Mixer	.975
	NHC Wash Tank	.997
	NHC Purification	.985
	NHC Distillation	.99
Waste Disposal		
.970	Incinerator	.975
	Tanks and Pumps	.995
Utilities		
.990	Steam, N2, Water, Gas	1.00
	Cooling Water, Air, Power	.99

AI = A B-10 X A NHC X A WD X A UT

AI = .995 X .9243 X .97 X .99

AI = .883

Design Basis: 30,000 lb./300 Stream Day Yr.

A I.D. = 300/365 = .822

Predicted System Availability, .883 Requires 300/.883 or 340 days per yr. scheduled operation. This would permit two week annual maintenance shutdown.

*B-10 Reactor Loops not critical if availability is not less than overall system.

RAM ANALYSIS

General

As required by the Contract TR 6116, a RAM Analysis Report (Data Item A00F) has been prepared according to DI-R 3535/R103-2M with Addendum and is given in its entirety in Appendix C. A brief summary of the RAM Analysis is given below.

RAM Analysis Summary

The appended report outlines the RAM parameters employed in the design of the NHC facility and details their application to the various process operations and equipment subsystems. Availability goals were established utilizing a block diagram of the facility and availability was apportioned to the critical systems (B10, NHC, Waste Disposal and Utilities) as shown in Table 4. Based on knowledge of operating conditions, equipment function and construction materials, each major subsystem was examined and assigned a predicted availability, also shown in Table 8 . The predicted overall system availability of 0.883 allows annual two week shutdown for major maintenance as well as allowing some time for unanticipated maintenance downtime.

The RAM analysis shows that the facility will be available for sufficient operating periods to meet contractual production requirements. Major subsystems incorporate design features that provide high availability with good reliability and maintainability. Callery's experience in handling toxic and flammable chemicals has demonstrated that high reliability and maintainability are necessary to assure safe operability.

These same considerations also lead to a facility that will provide the necessary 15 year operating life and will allow shutdown, layaway and restart without undue

expense and with minimal hazard. Long term storage will have no significant effect on system reliability. Some equipment items would be partially dismantled for storage but the majority of the equipment would only require thorough cleaning, inerting and sealing. Reactivation would require probable replacement of seals and gaskets followed by thorough leak testing of the entire system.

PLANT PROCEDURES

Start Up Procedures

Before the completion of construction of the NHC facility, Callery Chemical Company will complete the preliminary start up procedures necessary to commission the plant and accept the plant at the turnover from the primary contractor, Dravo Corporation. Detailed planning, technical competence and firm direction will insure a successful startup.

During the early months of construction, Callery's function in construction will be the monitoring of progress and witnessing the necessary testing of concrete and steel which is placed. During this time equipment and operating manuals will be received. Detailed maintenance procedures and schedules for each piece of equipment and preliminary operating instructions can be written at this time. All of the information available on the design, construction and operation of the facility will be organized so that it is easily accessible for startup. The design basis and engineering standards, process description and flow sheets, material and utility balances, plant equipment, piping and utilities layouts, operating maintenance and safety procedures and analytical procedures will be included. This basically encompasses the information from the final design report and the details of construction and the information received during construction. Batch process log sheets will be designed so that start up and operation data can be obtained. The various engineering, operations management maintenance and laboratory groups will be organized and keyed to the progress of the construction schedule.

After the process equipment is placed and process piping and electrical conduit runs are started, Callery's involvement in the construction progress becomes more critical. Many of the instruments to be placed will be checked before installation. Thermocouples will be checked to insure that they are reading properly. Rotameters will be calibrated generally

by calculation of density differences and the supplied curves rather than by actual flow measurement. Pressure and vacuum gages will be checked to guarantee proper operation. These instruments will be less accessible after installation.

Pressure testing of equipment and piping is to be performed by Dravo before the completion of construction. Callery personnel will verify the tests, especially in critical process areas. Since many of the lines will contain reactive borane chemicals, these must be cleaned before the introduction of any process fluid. After various sections of the plant become available after pressure testing, they will be flushed with a petroleum solvent such as naptha to remove any corrosion protection oils, then rinsed with a hygroscopic solvent such as methanol to pick up any water before drying with nitrogen. This will be done on the diborane lines from the Callery plant, the B-10 process piping and equipment and parts of the NHC building. The naptha flush will also remove any scale, dirt and metal particles which might have entered the system during construction. Process equipment will be inspected before sealing for pressure testing to check for dropped tools, bolts and other debris.

Operators will have started training before the clean out operations. These cleaning procedures will aid in the familiarization of some of the conceptually new equipment for the operators. They will be trained in standard operating and maintenance procedures and emergency shutdown and safety procedures. Operator training will be ongoing through the systems checkout before startup and continue through the startup phase.

Power and control electrical systems will be checked out by the contractor after installation. Instrument maintenance personnel and electricians will be present to insure that power systems are operating properly and grounded. The control circuits and switching logic of the B-10 reactor washout vent system will be checked by simulation to insure that the

valves are operating in the correct position and in proper sequence. Other control circuits will be tested by simulation. A checklist is provided for commissioning of instrument circuits.

Dry run testing of mechanical equipment will be performed to guarantee proper rotational direction under no load conditions. These checks will also verify free and unhindered rotation of impellers, shafts and agitators. These will be of short duration to prevent damage to equipment. A checklist is provided for commissioning mechanical equipment.

Dynamic testing will be performed on the process system using inert fluids. These tests will aid in determining that the flow through the process is correct and operable. Flow controls and pressure controls can be set more accurately. Measuring tanks will be calibrated by straight side calculations and by filling with known volumes of liquid. Temperatures approaching operating conditions will be used to determine the effectiveness of temperature controllers and thermocouples.

The B-10 system loops will undergo dynamic testing with gases which simulate diborane characteristics. Procedures followed will be based on those investigated in the reactor loop development effort. Usage of nitrogen and hydrogen and mixtures thereof were found to provide good simulation of reaction gas behavior for determining proper thermocouple probe locations and furnace temperature settings.

Dynamic testing will permit the setting or adjusting of standard operating procedures. Flow and pressure settings on rotameters and regulators will be set. The dynamic testing will be a great advance in operator training. Data recording will be standardized and it will be determined if the proper amount and necessary information is being recorded.

In preparation for the introduction of borane process fluids, the process equipment will be thoroughly dried and inerted. Boranes will be introduced only after dynamic testing

has shown the system to be capable of safe production and the operators are thoroughly trained in operating and safety procedures. Extra technical and operating personnel should be available for the startup of process fluids through the system. The process will be monitored carefully and the plant can be shutdown at any indication of upset or overload. Process flows will be increased gradually until the Options I and II demonstration levels can be met.

We will have on hand experts from the incinerator manufacturer to train the waste disposal personnel in the proper operating and emergency procedures for the incinerator. They will oversee the startup of the incinerator and dust collection system to aid in resolving any operating difficulties with this large and complex system.

With the startup procedures above, there should be a successful and incident free startup.

Start Up Checklist

1. Organize the groups who will participate in commissioning
2. Organize the necessary information
3. Prepare detailed plans and schedules
4. Train the personnel
5. Perform pressure tests
6. Perform dry runs
7. Perform dynamic safe fluid testing
8. Pressure test to prepare for the introduction of boranes.
9. Perform process fluid tests
10. Perform process fluid tests
11. Operate processes to make NHC
12. Troubleshoot and make performance analyses
13. Maintain the plant and make modifications

Instrument Commissioning Checklist

1. Assure that all elements are installed according to the drawings
2. Remove shipping restrictions and protective coverings

3. Recalibrate the instrument
4. Verify circuit continuity to and from panel
5. Verify valve and controller movement
6. Check out interlock and alarm action

Mechanical Equipment Checklist

1. Field disassembly and reassembly
2. Cleanout of lubrication system
3. Circulation of lubricant to check flow and temperature
4. Cleanout and checkout of cooling water system
5. Checkout of instruments
6. Checkout of free and unhindered rotation
7. Tightening of anchor bolts
8. Installation of temporary filters
9. Preparation for running at a load
10. Operate with driver uncoupled
11. Recoupling of driver and check alignment
12. Checkout vent system
13. Checkout seal system
14. Operate empty to check for vibration
15. Operation under load

Maintenance Procedures

Preventive and repair maintenance of process equipment and supporting services will be daily functions at the NHC facility. The facility will be staffed by a maintenance crew of trained mechanics and will be supported by the maintenance, instrument and electrical crews of Callery Chemical and Mine Safety Appliances. Most of the maintenance is to be performed on-site with tools and spare parts available in the process area.

The maintenance staff will include mechanical repair personnel and electricians. The mechanical staff will be responsible for maintaining the process equipment, piping and hardware, and the facility physical plant and supporting equipment. The electricians will be responsible for the electrical and electronic hardware plus the testing of circuitry for new equipment installations.

Detailed records of maintenance services for each piece of process equipment will be kept. This will aid in the restructuring of preventive maintenance services if the failure rate is higher than normal. These records will also aid in the selection of any new equipment which needs to be installed, either as replacement or to improve process operability and reduce costs. Repair services will require a form stating the piece of malfunctioning equipment, the suspected repair necessary if known or the mode of failure, and an authorization by the production supervisor. On this form the failure can be noted when corrected and the repair man hours can be reported. These sheets will not only allow the updating of the equipment records but will also assist in the assignment of the maintenance staff for their work day. The criticality of the failed equipment will be the determining factor in the assessment of repair priorities. The availability of the plant to meet production demands will dictate the distribution of the work force to preventive and repair maintenance tasks.

After the equipment orders are placed, the vendors will be required to send operations' manuals for the equipment being requisitioned. These manuals will provide the basis for the delineation of operating procedures for each piece of equipment, and the listing of spare parts to be carried in stock. These manuals will also be used to set the schedules for lubrication of rotating equipment and other preventive maintenance procedures. Repair maintenance procedures for the various failure modes will be based on the manufacturers information (See Exhibit "A" - Maintenance Procedures for the NHC Residue Pump #41224 from Selected Vendor).

As much repair work as possible will be performed at the location of the failed equipment in the process area. There is no specified repair shop at the NHC plant so that the equipment must be repaired in place or adjacent to the process positioning or removed to the Callery repair shops down the hill. The construction by Dravo of the fully piped process model will allow for adequate spacing for repair maintenance to be performed "on the floor". Spare parts will be stored in one of the bays of the process area for easy availability. An instrument maintenance shop will be established in part of the laboratory in the NHC building calibration tests and repair maintenance can be performed in this area as well as providing an area for small instrument parts storage.

Due to the toxic and flammable nature of most of the process raw materials and intermediates, equipment will be washed out with an appropriate solvent and dried with nitrogen before process equipment internals can be repaired. Drain valves are provided wherever applicable to aid in the washout of equipment. Extensive lockout procedures will be used by maintenance personnel to protect the equipment being repaired and to prevent personal injury. Safety locks will be provided to the mechanics to allow convenient lockout for safety.

Detailed maintenance procedures will be provided after equipment manuals are provided by the vendors. A general summary of typical maintenance procedures is provided by equipment groups.

312 -- Condensers: Flush with solvent and purge dry, disconnect piping, remove head. Inspect tubes for plugging or leakage. Clean tubes and plug bad tubes, if necessary. Reassemble and pressure test.

322 -- Packed Towers: High pressure drop - fouled packing; flush packing with solvent, nitrogen dry, support column from overhead, remove inlet/outlet piping, unbolt column from kettle, lift off column and support plate, dump packing and thoroughly clean and dry or replace with new packing. Reverse procedure adding packing; if necessary, replace gaskets and pressure test.

352 -- Unagitated Tanks: Drain and wash, purge dry. Remove inlet/outlet pipe connections, remove access port head, sight glass, manway, repair and reassemble using new gaskets.

362 --,
392 -- Agitated Vessels and Agitators: Lock out electrically, drain and wash purge dry. Support agitator, remove coupling, disassemble and remove seals. Examine bearings and replace, examine seals and replace. Reassemble.

412 -- Pumps: Lockout and drain, block lines, disconnect coupling, disassemble and remove seals, shaft and impeller. Examine and/or replace seals, bearings, shaft sleeve and other wearing parts. Reassemble and leak test.

422 -- Compressors and Vacuum Pumps: Lockout, disassemble and examine and/or replace wearing parts and seal elements. Reassemble with new seals and gaskets.

442 -- Heating and Cooling: Lock out and block feed lines; Disassemble malfunctioning portion of equipment, solvent clean and inspect/replace worn parts, inspect fan and motor bearing. Reassemble using new seals and gaskets.

452 -- Filters: Flush and dry, block inlet/outlet lines, unbolt filter, replace element if necessary. Reassemble with new gaskets.

472 -- Package Systems:

1) Water Treatment Unit: Isolate unit, replace controls or repair other malfunctions. Reassemble
2) Boiler Chemical Treatment: Normal pump maintenance
3) Condensate Return Units: Normal tank and pump maintenance
4) Deaerator: Isolate unit and drain, remove nozzle piping and inspect/replace nozzles, inspect trays. Reassemble
5) Instrument Air Drier: Isolate element not in service, remove cover, replace media, replace cover with new gaskets, pressure test.
6) Vacuum Distillation Unit: Lockout and block piping, clean with solvent and dry. Perform normal agitated vessel, column, tank and vacuum maintenances. Rebuild using new gaskets and seals.
7) Seal Oil Units: Lock out, drain oil; perform normal pump and filter maintenance. Reassemble with new seals and gaskets and replace oil.

492 -- Uninstalled Equipment: Fork truck perform normal tuneup, check hydraulic oil, wheel bearings. Lubricate.

HEAVY-DUTY BRACKET MOUNTED PUMPS

~~ATTACHMENT~~ Exhibit A
NHC Residue Pump
#41224 Area 40
Model H 4124

124 AND 4124 SERIES

— MAINTENANCE AND REPAIR INSTRUCTIONS

INTRODUCTION

The illustrations used in this maintenance bulletin are for identification purposes only and *should not be used for ordering parts.* Secure a parts list from the factory or a Viking representative. Always give complete name of part, part number and material with the model and serial number of the pump when ordering repair parts.

UNMOUNTED PUMP AND UNIT MODEL NUMBERS

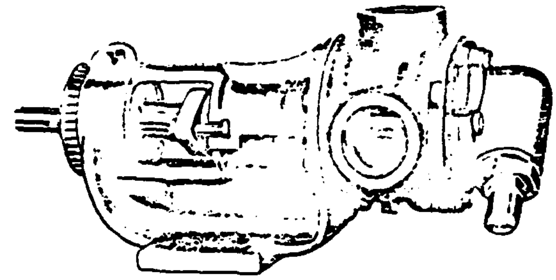
UNMOUNTED PUMP		UNITS
PACKED	MECH. SEAL	
H124 HL124 K124 KK124 L124 LQ124 LL124 Q124 M124	H4124 HL4124 K4124 KK4124 L4124 LQ4124 LL4124 Q4124 M4124	Units are designated by the unmounted pump model numbers followed by a letter indicating drive style. V=V-Belt D=Direct Connected R=Viking Speed Reducer P=Commercial Speed Reducer

This bulletin deals exclusively with Series 124 and 4124 heavy duty bracket mounted pumps. Refer to Figures 1 thru 5 for general configuration and nomenclature used in this bulletin.

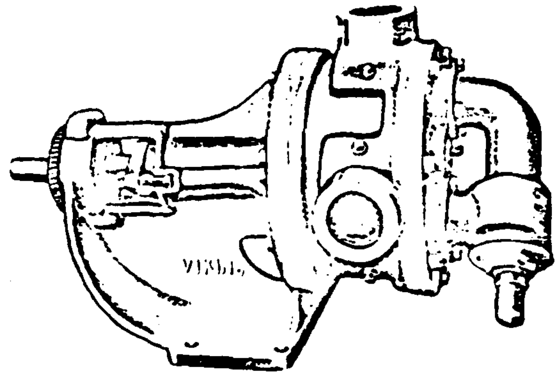
Maintenance

Series 124 and 4124 pumps are designed for long, trouble free life under a wide variety of application conditions with a minimum of maintenance, however, the following should be considered.

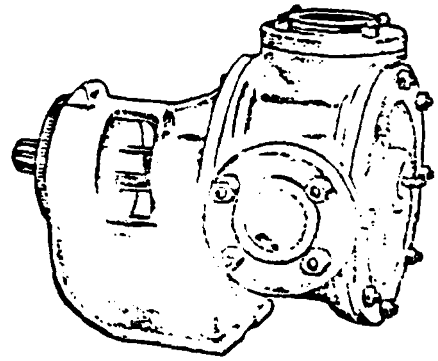
1. LUBRICATION—Periodic external lubrication should be applied slowly with a hand gun at all lubrication fittings provided. A good quality of general purpose grease is satisfactory in the majority of cases, however, applications involving very high or low temperatures may require other types of lubricants. Suggested frequency of lubrication is once every 500 hours of operation. Do not over-grease. Consult the factory if you have specific lubrication questions.
2. PACKING ADJUSTMENT—New packed pumps generally require some initial packing adjustment to control leakage as packing "runs-in". Make initial packing adjustments carefully and do not overtighten the packing gland. After initial adjustment occasional inspection will reveal the need for packing gland adjustment and/or replacement of the packing. See instructions in disassembly and re-assembly regarding re-packing the pump.
3. END CLEARANCE ADJUSTMENT—After long term operation it is sometimes possible to improve the performance of the pump, without major repair, thru adjustment of end clearance of the pump. Refer to instructions under Re-assembly of the pump for information regarding this procedure.
4. CLEANING THE PUMP—It is good practice to keep the pump as clean as possible. This will facilitate inspection, adjustment and repair work and help prevent omission of lubrication to fittings covered or hidden with dirt.



SIZES H AND HL
FIGURE 1



SIZES K, KK AND L
FIGURE 2



SIZES LQ, LL, Q AND M
FIGURE 3

HEAVY-DUTY BRACKET MOUNTED PUMPS

124 AND 4124 SERIES

MAINTENANCE AND REPAIR INSTRUCTIONS

5. STORAGE—If the pump is to be stored or not used for any appreciable length of time it should be drained and a light coat of lubricating and preservative oil should be applied to the internal parts. Lubricate all fittings.

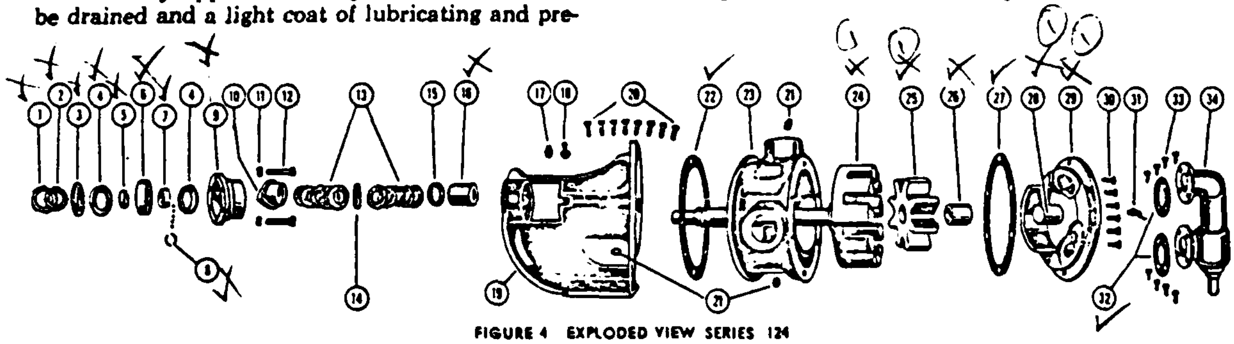


FIGURE 4 EXPLODED VIEW SERIES 124

SERIES 124

ITEM	NAME OF PART	ITEM	NAME OF PART	ITEM	NAME OF PART
1	Locknut	13	Packing	24	Rotor and Shaft
2	Lockwasher	14	Lantern Ring	25	Idler and Bushing
3	End Cap for Bearing Housing	15	Packing Retainer Washer	26	Idler Bushing
4	Closure, Bearing Housing	16	Bracket Bushing	27	Head Gasket
5	Bearing Spacer Collar	17	Pressure Relief Plug	28	Idler Pin
6	Ball Bearing	18	Grease Fitting	29	Head and Idler Pin
7	Bearing Spacer Collar, Recessed	19	Bracket and Bushing	30	Capscrew for Head
8	Keeper Ring Halves	20	Capscrew for Bracket	31	Grease Fitting (Angle)
9	Bearing Housing with Setscrews	21	Pipe Plug	32	Relief Valve Gasket
10	Packing Gland	22	Back Flange Gasket	33	Capscrew for Valve
11	Packing Gland Nut	23	Casing	34	Internal Relief Valve
12	Packing Gland Capscrew (Studs on Q & M)				

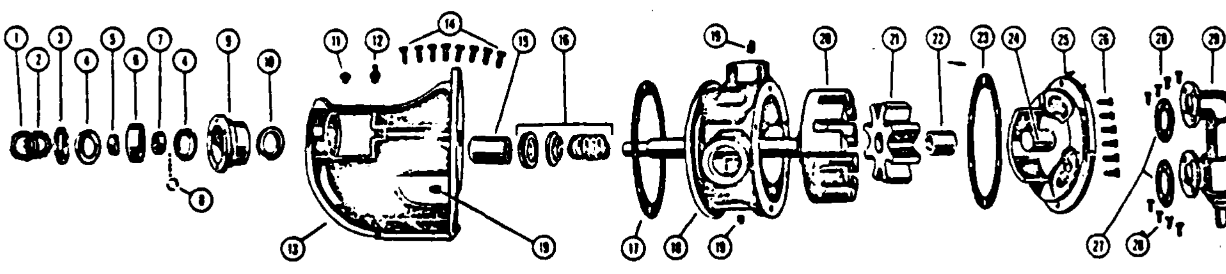


FIGURE 5 EXPLODED VIEW SERIES 4124

(SEE LIST OF PARTS, NEXT PAGE)

SERIES 4124

ITEM	NAME OF PART	ITEM	NAME OF PART	ITEM	NAME OF PART
1	Locknut	11	Pressure Relief Plug	21	Idler and Bushing
2	Lockwasher	12	Grease Fitting	22	Idler Bushing
3	End Cap for Bearing Housing	13	Bracket and Bushing	23	Head Gasket
4	Closure Bearing Housing	14	Capscrew for Bracket	24	Idler Pin
5	Bearing Spacer Collar	15	Bracket Bushing	25	Head (Plain) and Idler Pin
6	Ball Bearing	16	Mechanical Seal	26	Capscrew for Head
7	Bearing Spacer Collar, Recessed	17	Back Flange Gasket	27	Relief Valve Gasket
8	Keeper Ring Halves	18	Casing	28	Capscrew for Valve
9	Bearing Housing with Setscrews	19	Pipe Plug	29	Internal Relief Valve
10	Closure for Seal Chamber	20	Rotor and Shaft		

NOTE: Do not order parts by item numbers shown; see parts list on specific pump model.

Disassembly

1. Remove the head from the pump.

CAUTION: DO NOT ALLOW THE IDLER TO FALL FROM THE IDLER PIN.
Tilting the head up as it is removed will prevent this occurrence. Avoid damaging the head gasket if possible. If pump is furnished with a relief valve it need not be removed from head or disassembled at this point. (See page 6 for Valve Instructions.)

2. Remove the idler and bushing assembly from the idler pin. Replace all excessively worn parts. See caution about replacement of carbon bushings following #13.
3. Bend up tang on lockwasher and, using a spanner wrench, remove the lockwasher and locknut.

NOTE: A piece of wood or brass inserted between the rotor teeth and into the casing port will prevent the shaft from turning.

4. Loosen packing gland nuts on model 124 pumps.
5. Drive the shaft forward approximately ½ inch and inspect for presence of a pair of half-circle, round, wire, keeper rings under the inner bearing spacer collar. If present these rings must be removed before the rotor and shaft can be removed from the pump.
6. Carefully remove the rotor and shaft from the pump.

NOTE: Avoid damaging the bracket bushing. The rotary portion of the mechanical seal will usually come out with the shaft on model 4124 pumps. Remove the stationary seal seat from the bracket counterbore. Replace rotor and shaft if excessively worn.

7. Loosen the radial set screws in the bearing housing flange that locks the end cap in place and, using a spanner wrench, remove the end cap, closure and bearing spacer collar.
8. Remove 2-row ball bearing and inner spacer collar from bearing housing, wash and inspect bearing for wear or damage and replace, if necessary.
9. Loosen two axial set screws in bearing housing flange and remove housing from bracket. Examine closures in end cap and bearing housing and replace with lips facing as shown in Figure 11 if not in first class condition.
10. On 4124 model pumps, inspect the closure in the bracket and replace if necessary. This closure must be removed if replacement of the bracket bushing is necessary. See Step 13.
11. If it is deemed necessary to replace bracket bushing and/or repack model 124 pumps, remove packing gland nuts, old packing and lantern ring (not used on Q and M 124's) and packing retainer washer. See Step 13.
12. Examine casing for excessive wear and replace if necessary.
13. The bracket bushing should be inspected for wear and replaced if necessary. See Steps 10 and 11.

If it is necessary to install a new carbon graphite bushing, extreme care should be taken to prevent breaking, as it is a brittle material and easily cracked. If cracked these bushings will quickly disintegrate. An arbor press should always be used in installing carbon graphite bushings. Be sure the bushing is started straight. DO NOT STOP the pressing operation until the bushing is in proper position. Starting and stopping this operation invariably results in a bushing failure.
Carbon graphite bushings with extra interference fits are frequently furnished for high temperature operation. These bushings must be installed by a shrink fit. Heat bracket or idler to approximately 450°F. and install cool bushings with an arbor press. Check bushings for cracks after installation.

Reassembly

1. Installing new seal: The seal is simple to install and good performance will result if care is taken in installation. (See figure 6 for parts identification)

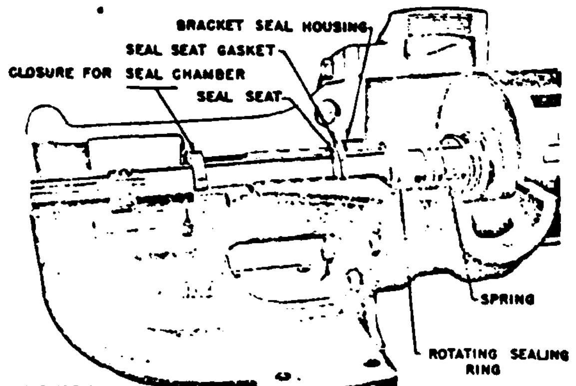


FIGURE 6

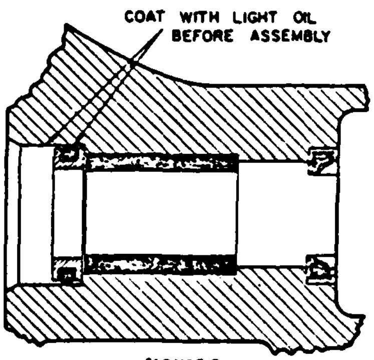


FIGURE 7

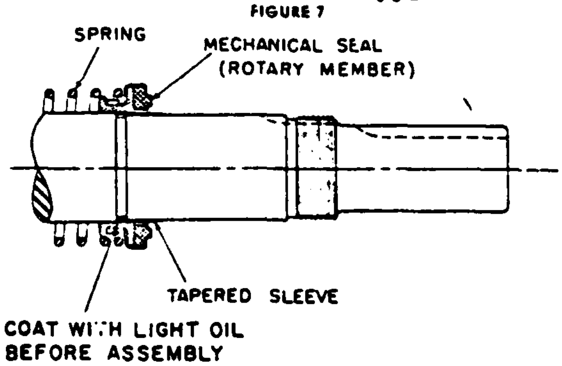


FIGURE 8

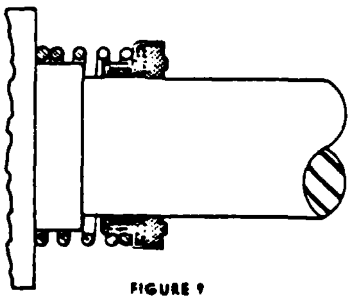


FIGURE 9

NOTE: Never touch the sealing faces with anything except the fingers or a clean cloth. Clean the rotor hub and bracket seal housing, making sure both are free from dirt and grit.
Coat the outside diameter of the seal seat and the inside diameter of the seal housing bore with light oil. With thumb and forefinger, push the seal seat into place, as shown in Figure 7. Place the tapered sleeve (furn with replacement seals,H-LL sizes) onshaft as in Figure 8. Coat the inside of the rotary member and the outside of the tapered sleeve with light oil. Place the spring and rotary member on the shaft, over the sleeve and against the hub of the rotor only enough to hold the spring in position. Do not compress spring at this stage. (See Figure 9.) Remove the tapered sleeve.

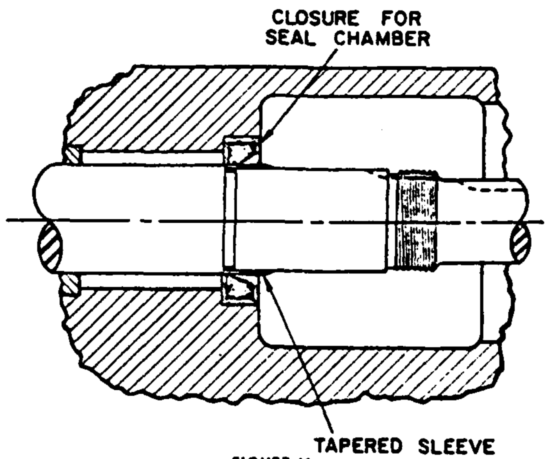


FIGURE 10

Refill the bracket lubrication chamber with multi-purpose grease and place the tapered sleeve in the closure (or seal chamber) as shown in Figure 10. Flush the sealing faces of both the rotary member and stationary member with oil just before installing rotor and shaft.

2. Install the rotor and shaft. Place the end of the shaft in the bracket bushing and turn from right to left slowly, pushing until the ends of the rotor teeth are just below the face of the casing. Be sure shaft is free from burrs and foreign particles that might damage the bracket bushing. Remove the tapered sleeve from the shaft(Model 4124).

3. On Model 124 pumps replace the packing retainer washer and pack the pump. It is good practice to install a set of new packing. The pump should be packed with a packing suitable for the liquid being pumped.

NOTE: If the pump has a lantern ring it must be located below the grease fitting. The grease fitting may be removed temporarily to facilitate positioning of the lantern ring. Cut the packing into individual

HEAVY-DUTY BRACKET MOUNTED PUMPS
124 AND 4124 SERIES

MAINTENANCE AND REPAIR INSTRUCTIONS

rings that wrap exactly around the circumference of the shaft. Install and seat each ring one at a time, staggering the ring joints from one side of the shaft to the other. Lubricate the packing rings with oil, grease or graphite to aid in assembly.
A length of pipe or tubing will facilitate installation and seating of the packing rings.

4. Install the packing gland, capscrews and nuts. Back the rotor and shaft out of the casing just far enough to insert the packing gland through the side opening on the bracket and over the end of the shaft. This gland cannot be assembled over the end of the shaft when in place. Push the rotor and shaft back into place.
   Make sure the gland is installed square and tighten nuts wrench tight, back off and retighten to a finger tight condition.
5. Place a head gasket on the head. The normal amount used on an H or HL size pump is one .010" gasket, and all other sizes one .015" gasket.
6. Place the idler on the idler pin and install the head and idler on the pump.
7. Place the bearing collar on the shaft as far as it will go. Replace keepers if furnished with pump.
8. Install the bearing housing and closure in the bracket.
9. Pack the ball bearing with grease, place on the shaft and push or drive into place in the housing.
10. Turn the bearing end cap (with closure and bearing collar inside) into the bearing housing until tight against the bearing. Lock in place by the setscrews in the outside diameter of the bearing housing.
11. Install lockwasher and locknut on shaft, tighten locknut and bend down tang of lockwasher into slot of locknut.

NOTE: A piece of brass or wood inserted through the port opening between the rotor teeth will keep the shaft from turning.

12. Adjust pump end clearance, following procedures listed under "Thrust Bearing Adjustment".

Thrust Bearing Adjustment

(See Figure 11)

1. Loosen the two set screws "A" in the outer face of the bearing housing "B" and turn this thrust bearing assembly "B" clockwise until it can no longer be turned by hand. Back off counterclockwise only until the rotor shaft can be turned by hand with a slight noticeable drag.

2. For standard end clearance, back off the thrust bearing assembly "B" the required number of notches or an equivalent length measured on the outside of the bearing housing. See the following table.

3. Tighten the two self locking type "Allen" set screws "A", in the outboard face of the bearing housing, with equal force against the bracket. Your pump is now set with standard end clearances and locked.

NOTE: Be sure the shaft can rotate freely. If not, back off additional notches and check again.

4. High viscosity liquids require additional end clearances. The amount of extra end clearance depends on the viscosity of the liquid pumped. For specific recommendations, consult the factory. Each additional notch (or each ¼") on the outside diameter of the bearing housing is equivalent to an extra end clearance of .002" on H & HL size pumps; .0015" on K, KK, L, LQ and LL pumps; .001" on Q and M pumps.

Pump Size	Turn Brg. Housing C.C.W. No. of Notches or Length on O.D., Inches	
H & HL	2	½"
K, KK, L, LQ, & LL	4	1"
Q	7	1¾"
M	9	2¼"

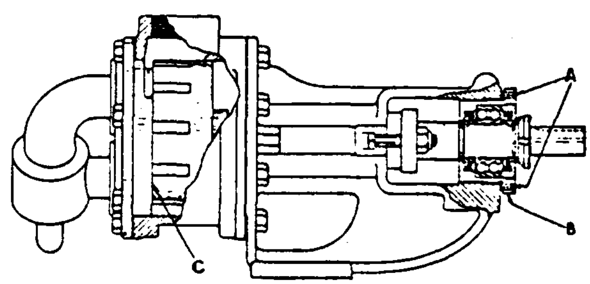


FIGURE 11

Steam Jackets

(See Figure 12)

As an added feature, Series 124 and 4124 Viking pumps may be equipped with a steam jacket on either the head, or back flange, or both. The construction of these jackets is such that the cored areas provide large chambers at both front and back of the working parts of the pump so as to facilitate temperature control for maintaining a flowing condition of the material being pumped. The jacketed back flange increases overall length slightly.
Pumps with jacketed heads cannot be furnished with relief valves. If a valve is required, it must be installed in the line.

HEAVY-DUTY BRACKET MOUNTED PUMPS
124 AND 4124 SERIES

MAINTENANCE AND REPAIR INSTRUCTIONS

All basic steps in disassembly and re-assembly of the pump remain the same whether or not it is equipped with steam jackets.

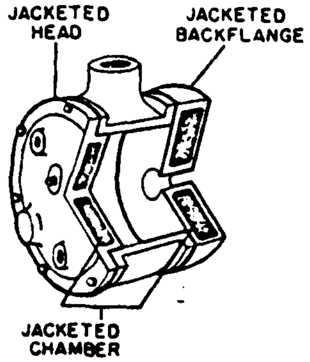


FIGURE 12

Valve Instructions

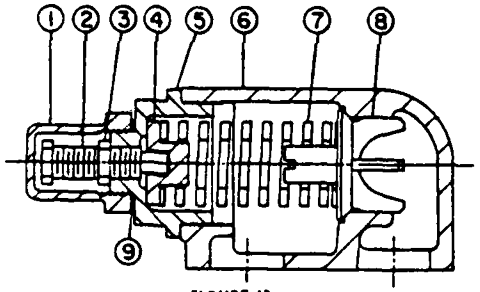
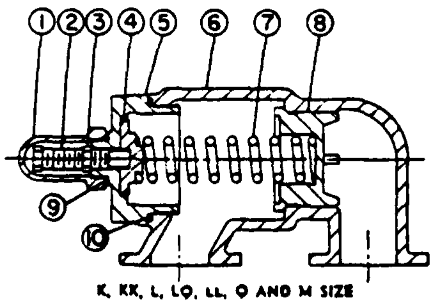


FIGURE 13
H AND HL SIZE



K, KK, L, LQ, LL, Q AND M SIZE
FIGURE 14

LIST OF PARTS

1. Valve Cap	6. Valve Body
2. Adjusting Screw	7. Valve Spring
3. Lock Nut	8. Poppet
4. Spring Guide	9. Cap Gasket
5. Bonnet	10. Bonnet Gasket

Disassembly

1. Remove valve cap.
2. Measure and record the length of extension of the adjusting screw.
3. Loosen the lock nut and back out adjusting screw until spring pressure is released.
4. Remove bonnet, spring guide, spring and poppet from valve body. Clean and inspect all parts for wear or damage and repair or replace as necessary.

Reassembly

Follow the procedure outlined under disassembly.
If valve is removed for repairs, be sure to replace in same position. The valve cap should point towards the suction port.

Pressure Adjustment

If the pressure setting of the valve is to be changed from that which the factory has set, the following instructions should be carefully followed: Remove the valve cap which covers the adjusting screw, and loosen the lock nut which locks the adjusting screw so pressure setting will not change during operation of pump. A pressure gauge somewhere in the discharge line must be used for actual adjustment operation. The adjusting screw should be turned in for increasing the pressure or turned out for decreasing the pressure. With the discharge line closed at a point beyond the pressure gauge, the gauge will show the maximum pressure the relief valve will allow while pump is in operation.

Important

In ordering parts for relief valve on head, always be sure to give Model and Serial Number of pump as it appears on name plate and the name of the part wanted. When ordering springs, be sure to give the pressure setting desired.

POWER EQUIPMENT COMPANY
8400 PERRY HIGHWAY
PITTSBURGH, PENNSYLVANIA 15237
412 - 931-5678

Repair Parts

After the initiation of operations in the new NHC facility the equipment that is installed will require occasional maintenance, both preventive and repair. Adherence to preventive maintenance schedules and procedures will minimize normal repair of wearing parts and emergency repair of failed parts. In order to facilitate timely repair to minimize downtime it will be necessary to stock a supply of repair parts for the new equipment.

When the equipment orders are placed, the vendor will be required to send detailed equipment operations manuals. These manuals will form the basis for exact operating procedures and maintenance procedures and also for an exact repair parts listing. A generalized outline of the necessary spare parts for plant operation can be provided at this time.

The construction of the facility hardware, process and utility piping will require the installation of large numbers of valves. Selection of valve types and sizes has been dictated by good engineering practice based on service conditions, operation safety and convenience, flow control and line sizing. Standardization of valves and fittings for various services is delineated in the Dravo piping specification P-1. A sufficient excess of valves and fittings will be ordered initially to allow for modification of piping during installation if necessary and so that spares will be available. The off the shelf items are readily replaceable. The majority of the valves in the plant are manually operated. Automatically switched valves are pneumatic solenoid operated. The actuators for these valves will be spared for easy replacement from stock.

Locally mounted visually indicating instruments (pressure and vacuum gages, thermometers, rotameters, etc.) will be stocked as replacement items. These must be stocked also as add on items where additional information about the process is required for control after startup. These are generally off the shelf items.

A supply of V-belts will be maintained for that equip-

ment which is belt driven. Bearings will be spared for ventilating fans. A large stock of fuses and other small electrical supplies for area maintenance will be carried.

The process equipment repair parts list will be detailed from vendor information supplied after orders are placed. Equipment groups have common items normally spared for repair maintenance. A listing by groups is provided.

312 -- Condensers: Gasket material, flow sight glass

322 -- Tower and Columns: Excess packing material, gasketing material, sight glass

352 -- Unagitated Tanks

1) Storage Tanks: Level indicator, manway gaskets, strainer if applicable
2) Measuring Tanks: Sight glasses, level gages, gasketing materials
3) Product Hoppers: Inlet/Outlet valves, gasketing materials

362 -- Agitated Tanks

1) Liquid Tanks: Sight glasses, level gages, gasketing

392 -- Agitators: Bearing sets, mechanical seal rebuild sets (wear faces, O rings, springs)

2) B10 Reactor Loops: Metering valves, heating mantles, heating controllers, cooling water control valves, scraper blades, mixer bearing sets, mechanical seals, rebuild sets, mixer motors

412 -- Pumps

1) Drum Pumps, Air Operated: Seals, O rings, packing, springs
2) Process Pumps, Centrifugal: Mechanical seals and rebuild sets, bearings, casing gaskets, wear ring, impeller and shaft if interchangeable.

422 -- Compressors, Vacuum Pumps:

1) Vacuum Pumps: Seals, gaskets, valve plates, bearings
2) Compressors: Bearings, seals, valves and springs, channels, gaskets

442 -- Heaters and Coolers:

1) Water Chiller: Compressor bearings, seals, refrigerant expansion valve, filters, tank level gage, pump bearings, seals and gaskets, control system parts.
2) Boiler: Atomizing nozzles, control system repair parts, combustion air blower bearings
3) Cooling Tower: Fan bearings
4) Incinerator: Atomizing nozzles, sight glasses, quench nozzles, filter bags, blower bearings, discharge valve bearings, gaskets and seals, control system repair parts.

452 -- Filters: Spare elements, gasket materials.

472 -- Package Systems:

1) Water Treatment: Control system repair parts
2) Boiler Chemical Treatment: Pump Bearings, seals and gaskets
3) Condensate Return: Pump bearings, seals and gaskets
4) Deaerator: Spray nozzles, control instrument repair
5) Instrument Air Dryer: Drying media
6) Vacuum Distillation Unit: Heat control elements, flow sight glass, level indicators, vacuum pump seals, valve plates, bearings gaskets
7) Seal Oil Units: Bearings, gaskets, mechanical seals and rebuild parts

492 -- Uninstalled Equipment: Fork truck wheels, tuneup parts

APPENDIX A

B10 Reactor Tradeoff

Technical requirements have dictated a design for the B10 production process based on multiples of a unit reactor consisting of 3 identical 4" ID loops in series. Correlation of experimental data on B10 yield as a function of B2 feed rate has shown the following relationship, where the B2 feed rate is expressed as lb per hr per ft^2 of heated surace in a single loop:

B2 Feed Rate ($lb/hr\ ft^2$)	Overall 3 Stage B10 Yield (% of Theory)	Unit Reactor B10 Production Rate (lb/hr)
0.02	78	0.059
0.05	68	0.126
0.10	61	0.227
0.15	57	0.315
0.20	54	0.399

Selection of the optimum number of reactors to achieve 30,000 lb/yr NHC production required a tradeoff between B2 utilization and the capital and operating cost of multiples of the unit reactor. Tradeoff calculations, discussed below in detail, indicated a process design consisting of the minimum number of reactors (12 for 30,000 lb/yr NHC production) operated at maximum productivity. This design selection minimizes both equipment cost and unit product cost.

No detailed estimate of equipment cost is presented, since any increase in the number of reactors beyond the minimum required for production will result in increased total equipment cost. Unit product cost tradeoff may be made by establishing a cost basis for the 12 reactor design and then calculating the incremental effects of operating labor and B2 costs as the number of reactors is increased from minimum to maximum. The range of yields shown in the previous table, which for 30,000 lb/yr NHC requires 12 reactors at maximum feed rate and approximately 81 reactors at minimum feed rate.

The basis for the unit product cost estimated for the design case (12 reactors) is the May 1976 estimate except for a usage rate of 2.16 lb B2 per lb NHC. This breakdown is shown in Table 1.

Incremental B2 costs are derived from the curve of Figure 1 s ..ing the B2 usage as a function of feed rate.

Incremental labor costs for increased number of reactors were calculated on the following basis:

1	Operator per shift per 4 additional reactors
1	M & R per shift per 12 additional reactors
0.5	Supervision per shift per 12 additional reactors

For reactor units added in increments of 12, each increment then requires additional direct labor:

Operators	3 x 4 = 12	@ $5.70/hr x 2080	=	$154,128
M & R	1 x 4 = 4	@ $5.70/hr x 2080	=	47,424
Supervision	0.5 x 4 = 2	@ $14,000/yr	=	28,000
				$229,552

On a unit cost basis direct labor is then

$229,552   30,000 = $7.65/lb NHC

Adding plant overhead (@ 175%) and repair materials and operating supplies (@ 15%) the total labor associated cost increase per increment of 12 reactors including G & A @ 18% and Fee @ 10% is $28.80/lb NHC.

Application of these incremental costs to the design base unit cost breakdown shows that each increment of 12 additional reactors results in a higher unit product cost as illustrated in Figure 2. Thus the design base of 12 reactors operating at maximum feed rate results in optimum unit cost.

Table 1 - Unit Product Cost Breakdown

12 Reactor Design, 30,000 lb/yr NHC

(May 1976 Cost Basis)

COST ELEMENT		$/LB NHC
Raw Materials excluding B2		$ 37.92
Solvents		3.37
Utilities		1.21
Direct Labor		22.50
Supervision	4 @ $14,000/yr	
Operators	32 @ $5.70/hr x 2080	
Maintenance & Repair	12 @ $5.70/hr x 2080	
Analytical	4 @ $6.50/hr x 2080	
Service	4 @ $5.20/hr x 2080	
Plant Overhead	175% of Direct Labor	39.38
Repair Materials and Operating Supplies	15% of Direct Labor	3.38
Packaging Materials		0.82
Sub Total		108.58
G & A	@ 18%	19.54
Fee	@ 10%	12.81
Unit Product Cost (excluding B2)		140.93
B2 2.16 lb/lb NHC x $85/lb		183.60
Unit Product Cost (including B2)		$324.53

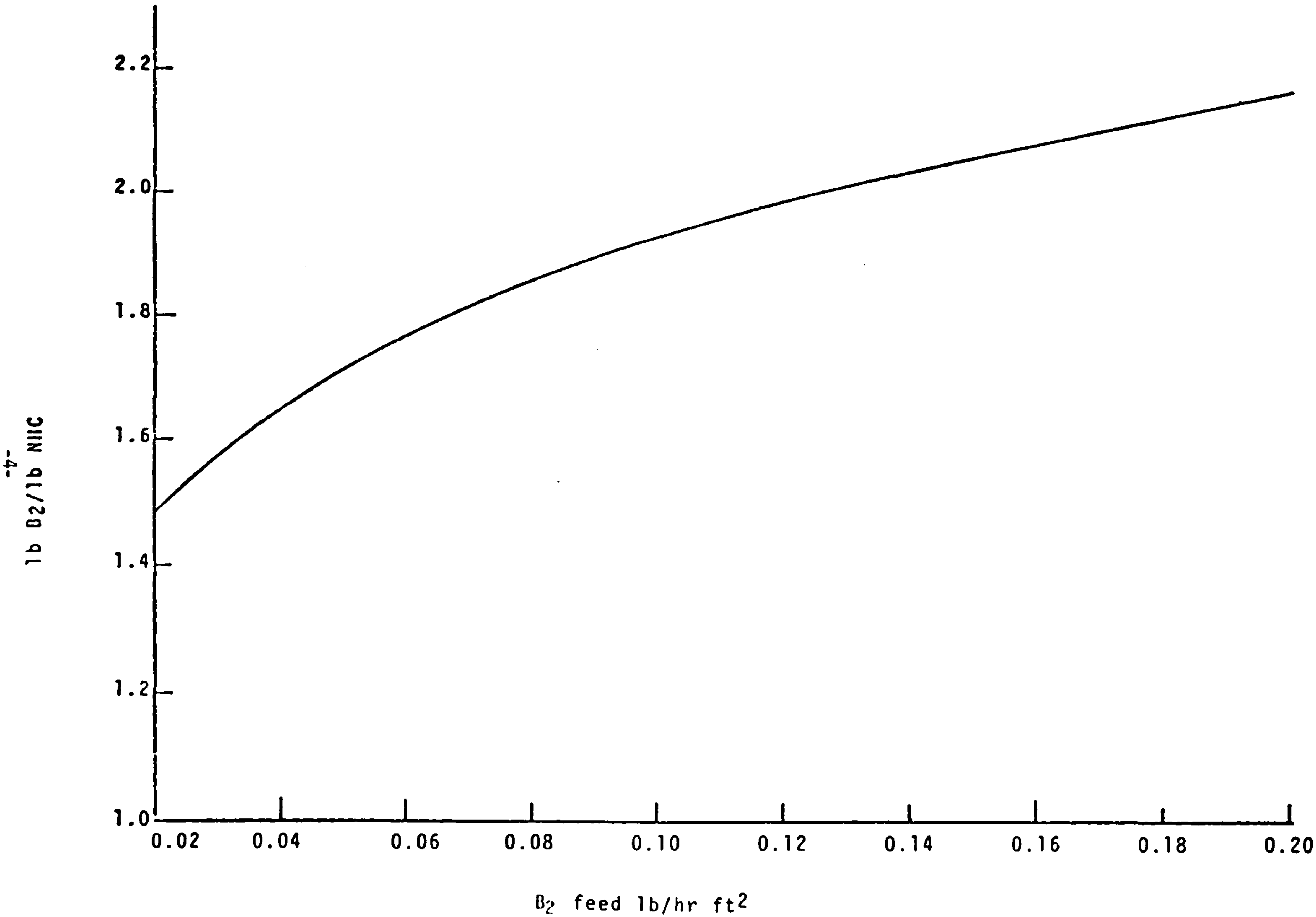


Figure 1 - B2 Usage vs Feed Rate

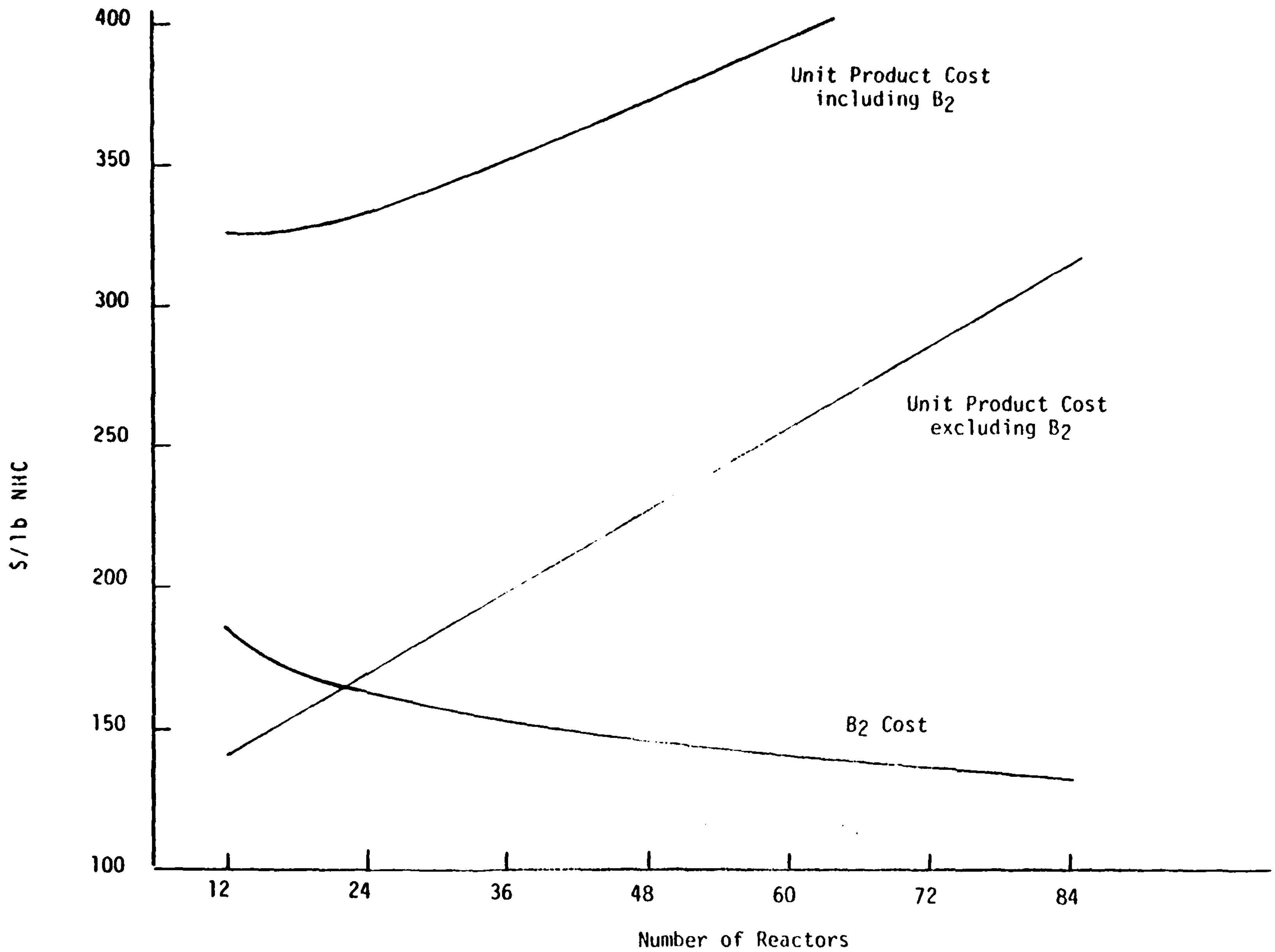
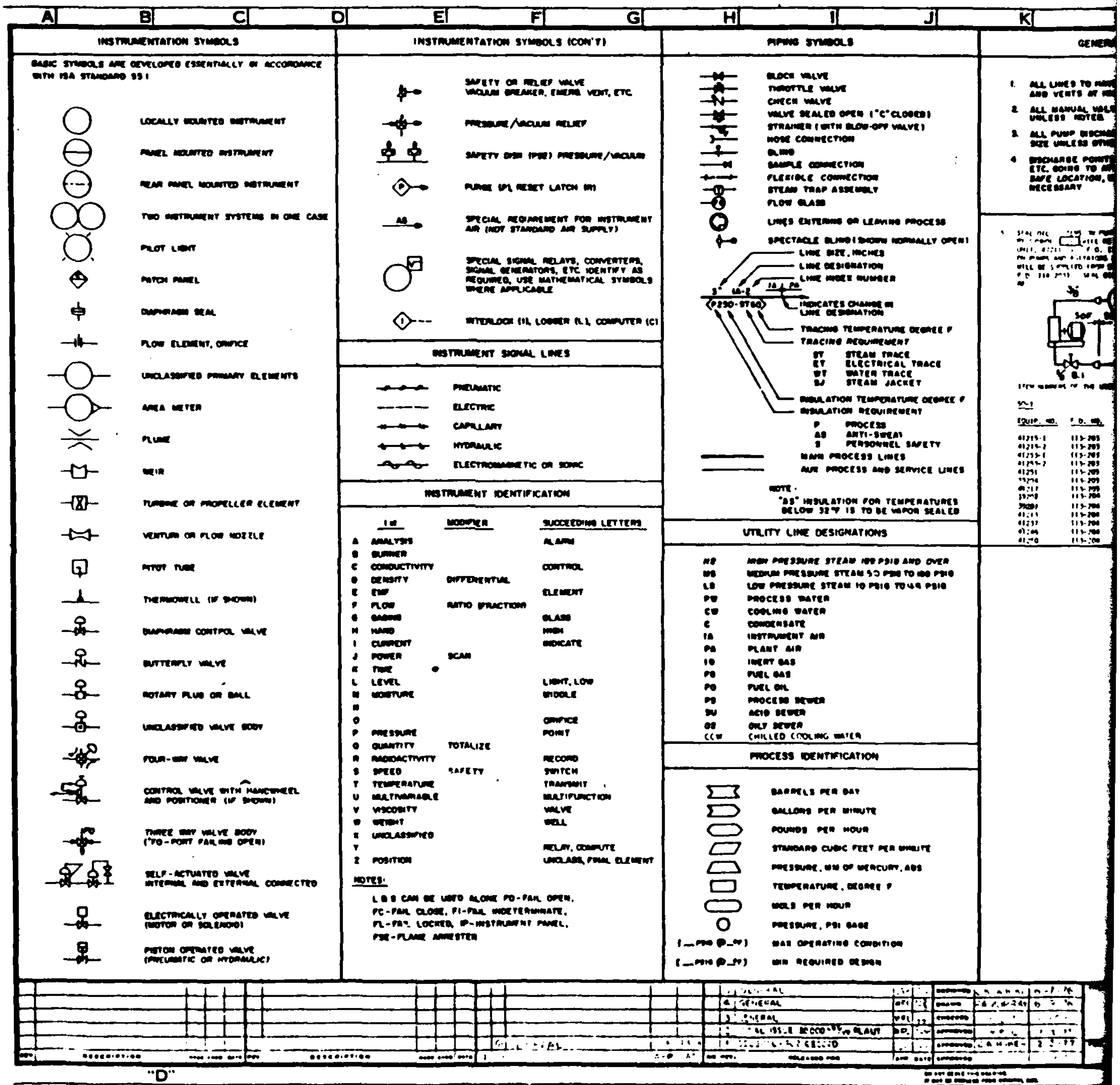


Figure 2 - Cost Variation with Number of Reactors

APPENDIX B

ENGINEERING FLOW DIAGRAMS



A B C D E F G H I J K
INSTRUMENTATION SYMBOLS
BASIC SYMBOLS ARE DEVELOPED ESSENTIALLY IN ACCORDANCE WITH ISA STANDARD S5.1
LOCALLY MOUNTED INSTRUMENT
PANEL MOUNTED INSTRUMENT
REAR PANEL MOUNTED INSTRUMENT
TWO INSTRUMENT SYSTEMS IN ONE CASE
PILOT LIGHT
PATCH PANEL
DIAPHRAGM SEAL
FLOW ELEMENT, ORIFICE
UNCLASSIFIED PRIMARY ELEMENTS
AREA METER
FLUME
WEIR
TURBINE OR PROPELLER ELEMENT
VENTURI OR FLOW NOZZLE
PITOT TUBE
THERMOWELL (IF SHOWN)
DIAPHRAGM CONTROL VALVE
BUTTERFLY VALVE
ROTARY PLUG OR BALL
UNCLASSIFIED VALVE BODY
FOUR-WAY VALVE
CONTROL VALVE WITH HANDWHEEL AND POSITIONER (IF SHOWN)
THREE WAY VALVE BODY ("FO-PORT FAILING OPEN)
SELF-ACTUATED VALVE INTERNAL AND EXTERNAL CONNECTED
ELECTRICALLY OPERATED VALVE (MOTOR OR SOLENOID)
PISTON OPERATED VALVE (PNEUMATIC OR HYDRAULIC)
INSTRUMENTATION SYMBOLS (CON'T)
SAFETY OR RELIEF VALVE VACUUM BREAKER, EMERG. VENT, ETC.
PRESSURE/VACUUM RELIEF
SAFETY DISK (PSE) PRESSURE/VACUUM
PURGE (P), RESET LATCH (R)
AS
SPECIAL REQUIREMENT FOR INSTRUMENT AIR (NOT STANDARD AIR SUPPLY)
SPECIAL SIGNAL RELAYS, CONVERTERS, SIGNAL GENERATORS, ETC. IDENTIFY AS REQUIRED, USE MATHEMATICAL SYMBOLS WHERE APPLICABLE
INTERLOCK (I), LOGGER (L), COMPUTER (C)
INSTRUMENT SIGNAL LINES
PNEUMATIC
ELECTRIC
CAPILLARY
HYDRAULIC
ELECTROMAGNETIC OR SONIC
INSTRUMENT IDENTIFICATION
1st | MODIFIER | SUCCEEDING LETTERS
A ANALYSIS | | ALARM
B BURNER
C CONDUCTIVITY | | CONTROL
D DENSITY | DIFFERENTIAL
E EMF | | ELEMENT
F FLOW | RATIO (FRACTION)
G GAGING | | GLASS
H HAND | | HIGH
I CURRENT | | INDICATE
J POWER | SCAN
K TIME
L LEVEL | | LIGHT, LOW
M MOISTURE | | MIDDLE
N
O | | ORIFICE
P PRESSURE | | POINT
Q QUANTITY | TOTALIZE
R RADIOACTIVITY | | RECORD
S SPEED | SAFETY | SWITCH
T TEMPERATURE | | TRANSMIT
U MULTIVARIABLE | | MULTIFUNCTION
V VISCOSITY | | VALVE
W WEIGHT | | WELL
X UNCLASSIFIED
Y | | RELAY, COMPUTE
Z POSITION | | UNCLASS. FINAL ELEMENT
NOTES:
L & S CAN BE USED ALONE FO-FAIL OPEN, FC-FAIL CLOSE, FI-FAIL INDETERMINATE, FL-FAIL LOCKED, IP-INSTRUMENT PANEL, FSE-FLAME ARRESTER
PIPING SYMBOLS
BLOCK VALVE
THROTTLE VALVE
CHECK VALVE
VALVE SEALED OPEN ("C" CLOSED)
STRAINER (WITH BLOW-OFF VALVE)
HOSE CONNECTION
BLIND
SAMPLE CONNECTION
FLEXIBLE CONNECTION
STEAM TRAP ASSEMBLY
FLOW GLASS
LINES ENTERING OR LEAVING PROCESS
SPECTACLE BLIND (SHOWN NORMALLY OPEN)
LINE SIZE, INCHES
LINE DESIGNATION
LINE INDEX NUMBER
P230-ST60
INDICATES CHANGE IN LINE DESIGNATION
TRACING TEMPERATURE DEGREE F
TRACING REQUIREMENT
ST STEAM TRACE
ET ELECTRICAL TRACE
WT WATER TRACE
SJ STEAM JACKET
INSULATION TEMPERATURE DEGREE F
INSULATION REQUIREMENT
P PROCESS
AS ANTI-SWEAT
S PERSONNEL SAFETY
MAIN PROCESS LINES
AUX. PROCESS AND SERVICE LINES
NOTE:
"AS" INSULATION FOR TEMPERATURES BELOW 32°F IS TO BE VAPOR SEALED
UTILITY LINE DESIGNATIONS
HS HIGH PRESSURE STEAM 100 PSIG AND OVER
MS MEDIUM PRESSURE STEAM 50 PSIG TO 100 PSIG
LS LOW PRESSURE STEAM 10 PSIG TO 50 PSIG
PW PROCESS WATER
CW COOLING WATER
C CONDENSATE
IA INSTRUMENT AIR
PA PLANT AIR
IG INERT GAS
FG FUEL GAS
FO FUEL OIL
PS PROCESS SEWER
SU ACID SEWER
OS OILY SEWER
CCW CHILLED COOLING WATER
PROCESS IDENTIFICATION
BARRELS PER DAY
GALLONS PER MINUTE
POUNDS PER HOUR
STANDARD CUBIC FEET PER MINUTE
PRESSURE, MM OF MERCURY, ABS
TEMPERATURE, DEGREE F
MOLS PER HOUR
PRESSURE, PSI GAGE
MAX OPERATING CONDITION
MIN REQUIRED DESIGN
GENER
1. ALL LINES TO HAVE ... AND VENTS AT HIG...
2. ALL MANUAL VALV... UNLESS NOTED
3. ALL PUMP DISCHA... SIZE UNLESS OTHE...
4. DISCHARGE POINTS ... ETC. GOING TO AT... SAFE LOCATION, ... NECESSARY
GENERAL
GENERAL
GENERAL
DESCRIPTION
DESCRIPTION
"D"

J K L M N O P

Q R S T U V W X Y Z

...BOLS

...ALVE
...D OPEN ("C" CLOSED)
...ITH BLOW-OFF VALVE)
...CTION
...ECTION
...CONNECTION
...P ASSEMBLY
...ING OR LEAVING PROCESS
...BLIND (SHOWN NORMALLY OPEN)
...SIZE, INCHES
...DESIGNATION
...SHEET NUMBER
...ITES CHANGE IN
...DESIGNATION
...ING TEMPERATURE DEGREE F
...ING REQUIREMENT
... STEAM TRACE
... ELECTRICAL TRACE
... WATER TRACE
... STEAM JACKET
...LATION TEMPERATURE DEGREE F
...LATION REQUIREMENT
... PROCESS
... ANTI-SWEAT
... PERSONNEL SAFETY
...D PROCESS LINES
... PROCESS AND SERVICE LINES
...LATION FOR TEMPERATURES
...50°F TO TO BE VAPOR SEALED

...DESIGNATIONS

...E STEAM 100 PSIG AND OVER
...RE STEAM 50 PSIG TO 100 PSIG
... STEAM 10 PSIG TO 49 PSIG

...NG WATER

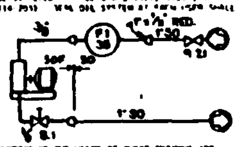
...NTIFICATION

... PER DAY
... PER MINUTE
... PER HOUR
... CUBIC FEET PER MINUTE
..., IN. OF MERCURY, ABS
...TURE, DEGREE F
...ER HOUR
...E, PSI GAGE
...ERATING CONDITION
...SIGNED DESIGN

GENERAL NOTES

1. ALL LINES TO HAVE DRAINS AT LOW POINTS AND VENTS AT HIGH POINTS.
2. ALL MANUAL VALVES TO BE FULL LINE SIZE UNLESS NOTED.
3. ALL PUMP DISCHARGE VALVES TO BE LINE SIZE UNLESS OTHERWISE NOTED.
4. DISCHARGE POINTS OF DRAINS, VENTS, PSV, ETC. GOING TO ATMOSPHERE MUST BE IN A SAFE LOCATION, WITH PIPE EXTENSION AS NECESSARY

5. SEAL OIL [illegible] TO PUMPS AND AGITATORS INDICATED BY SYMBOL [illegible] WILL BE SUPPLIED FROM SEAL OIL UNIT, 47211 [illegible] F.D. 115-205). SEAL OIL SYSTEM TO PUMPS AND AGITATORS INDICATED BY SYMBOL [illegible] WILL BE SUPPLIED FROM SEAL OIL UNIT, 47210, [illegible] F.D. 116-205). SEAL OIL SYSTEM AT EACH USER SHALL BE:



ITEM NUMBERS OF THE USERS OF THESE SYSTEMS ARE:

SO-1 EQUIP. NO.	F.D. NO.	SO-2 EQUIP. NO.	F.D. NO.
41219-1	115-205	39205 (PUT)	116-201
41219-2	115-205	39208	116-201
41299-1	115-205	39210	116-201
41299-2	115-205	39212	116-201
41291	115-205	41210 (PUT)	116-[illegible]
[illegible]	115-205	39207	116-202
[illegible]	115-205	39208	116-202
[illegible]	115-204	39209	116-202
[illegible]	115-204	41220	116-[illegible]
[illegible]	115-204	41274	116-204
[illegible]	115-204	47210-1 AGT.	116-204
[illegible]	115-204	47210-2 AGT. (PUT)	116-204
[illegible]	115-204		

RELEASED FOR CONSTRUCTION

DATE 3/8/77

ENGINEERING FLOW DIAGRAM

LEGEND

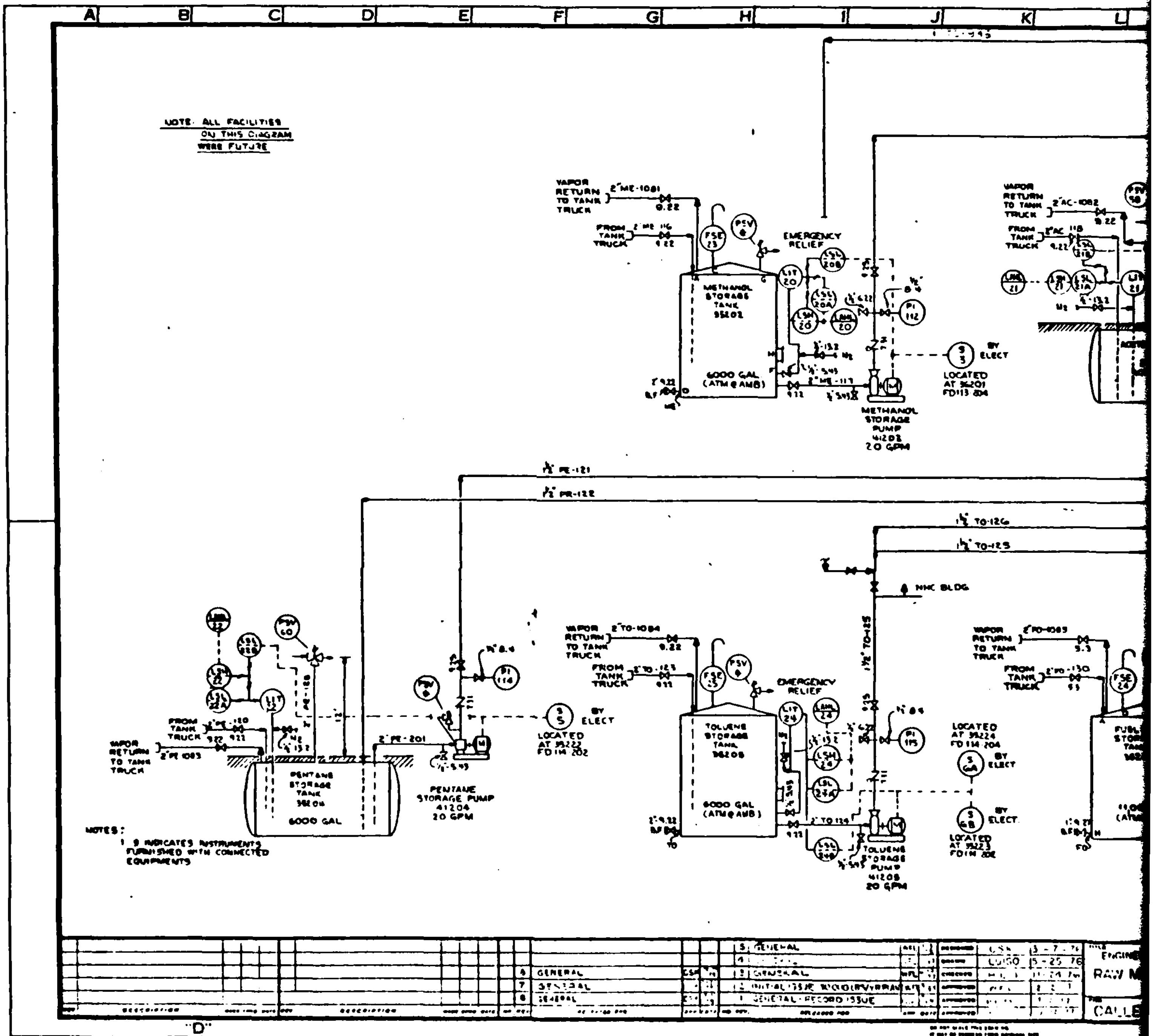
ALLERY CHEMICAL CO

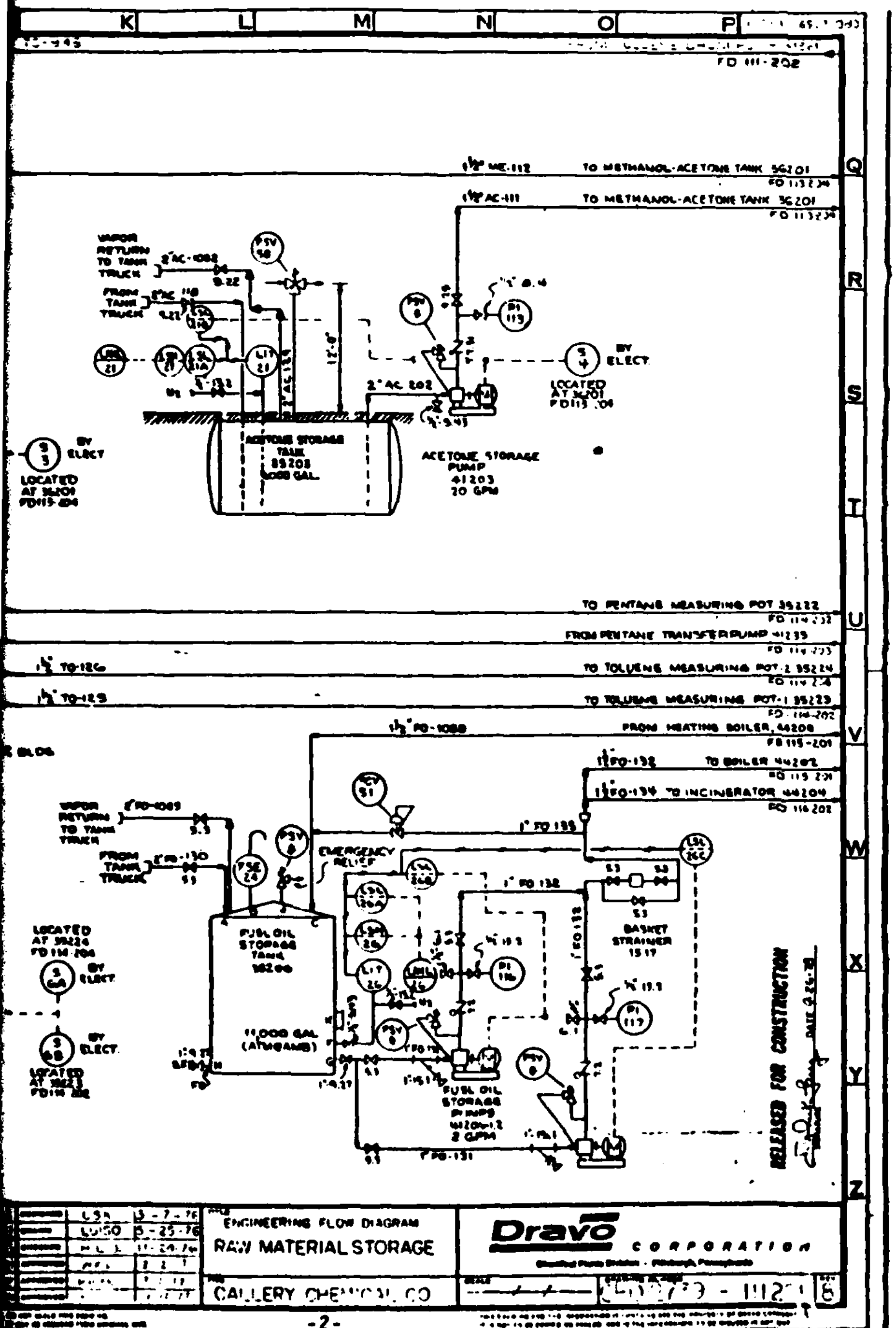
Dravo CORPORATION

CHD-2753 110-

-1-

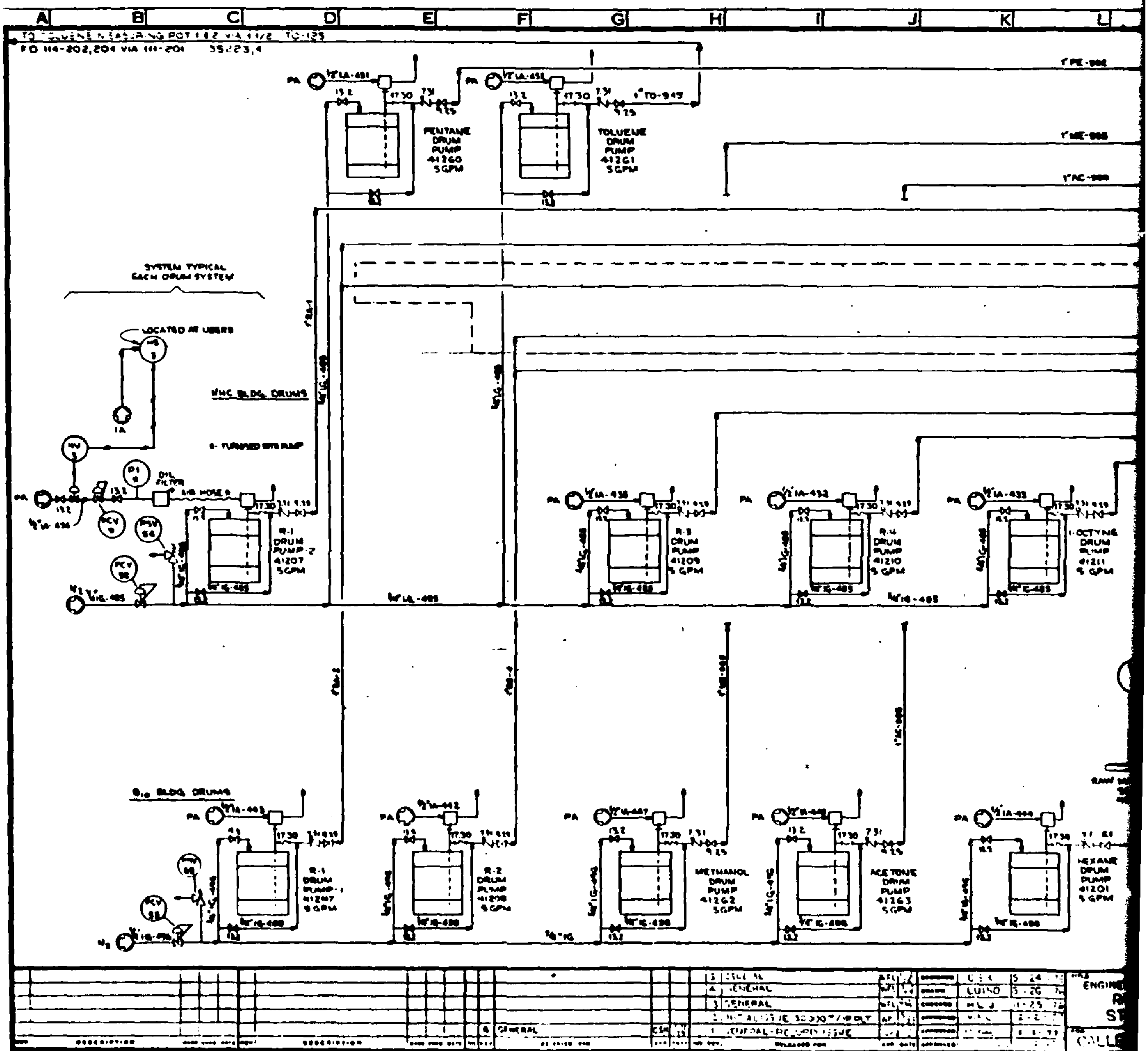
2


NOTE: ALL FACILITIES ON THIS DIAGRAM WERE FUTURE
VAPOR RETURN TO TANK TRUCK
2" ME-1081
FROM TANK TRUCK
EMERGENCY RELIEF
METHANOL STORAGE TANK 35202
6000 GAL (ATM @ AMB)
METHANOL STORAGE PUMP 41202 20 GPM
BY ELECT
LOCATED AT 35201 FD113 204
1½" PE-121
1½" PR-122
1½" TO-126
1½" TO-125
NHC BLDG
2" TO-1084
TOLUENE STORAGE TANK 35205
6000 GAL (ATM @ AMB)
TOLUENE STORAGE PUMP 41205 20 GPM
LOCATED AT 35224 FD114 204
LOCATED AT 35223 FD114 202
PENTANE STORAGE TANK 35204
6000 GAL
2" PE-201
PENTANE STORAGE PUMP 41204 20 GPM
LOCATED AT 35222 FD114 202
NOTES:
1. ⊘ INDICATES INSTRUMENTS FURNISHED WITH CONNECTED EQUIPMENTS
GENERAL
INITIAL ISSUE
GENERAL - RECORD ISSUE
"D"



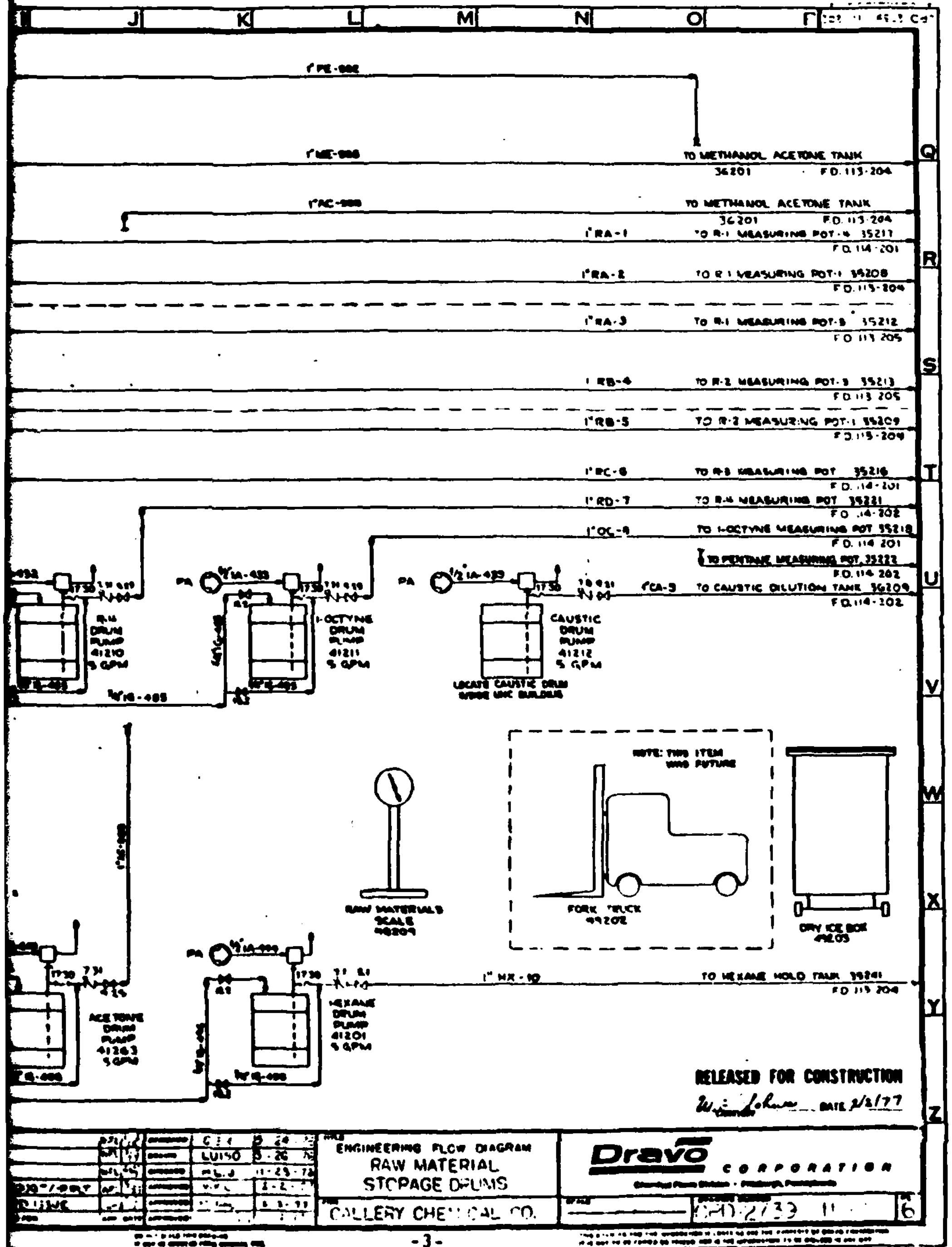
TO METHANOL-ACETONE TANK 36201
VAPOR RETURN TO TANK TRUCK
FROM TANK TRUCK
ACETONE STORAGE TANK 35203
ACETONE STORAGE PUMP 41203 20 GPM
BY ELECT.
TO PENTANE MEASURING POT 35222
FROM PENTANE TRANSFER PUMP 41235
TO TOLUENE MEASURING POT-2 35224
TO TOLUENE MEASURING POT-1 35223
FROM HEATING BOILER 44206
TO BOILER 44202
TO INCINERATOR 44204
EMERGENCY RELIEF
FUEL OIL STORAGE TANK 38200
11,000 GAL (ATM@AMB)
BASKET STRAINER
FUEL OIL STORAGE PUMPS
RELEASED FOR CONSTRUCTION
ENGINEERING FLOW DIAGRAM
RAW MATERIAL STORAGE
CALLERY CHEMICAL CO
Dravo CORPORATION

2



A
B
C
D
E
F
G
H
I
J
K
L
FO 114-202,204 VIA 111-201
PA
PENTANE DRUM PUMP 41260 5GPM
TOLUENE DRUM PUMP 41261 5GPM
SYSTEM TYPICAL EACH DRUM SYSTEM
LOCATED AT USERS
OIL FILTER
R-1 DRUM PUMP-2 41207 5GPM
R-3 DRUM PUMP 41209 5 GPM
R-4 DRUM PUMP 41210 5 GPM
1-OCTYNE DRUM PUMP 41211 5 GPM
R-1 DRUM PUMP-1 41247 5 GPM
R-2 DRUM PUMP 41298 5GPM
METHANOL DRUM PUMP 41262 5GPM
ACETONE DRUM PUMP 41263 5GPM
HEXANE DRUM PUMP 41201 5 GPM
GENERAL

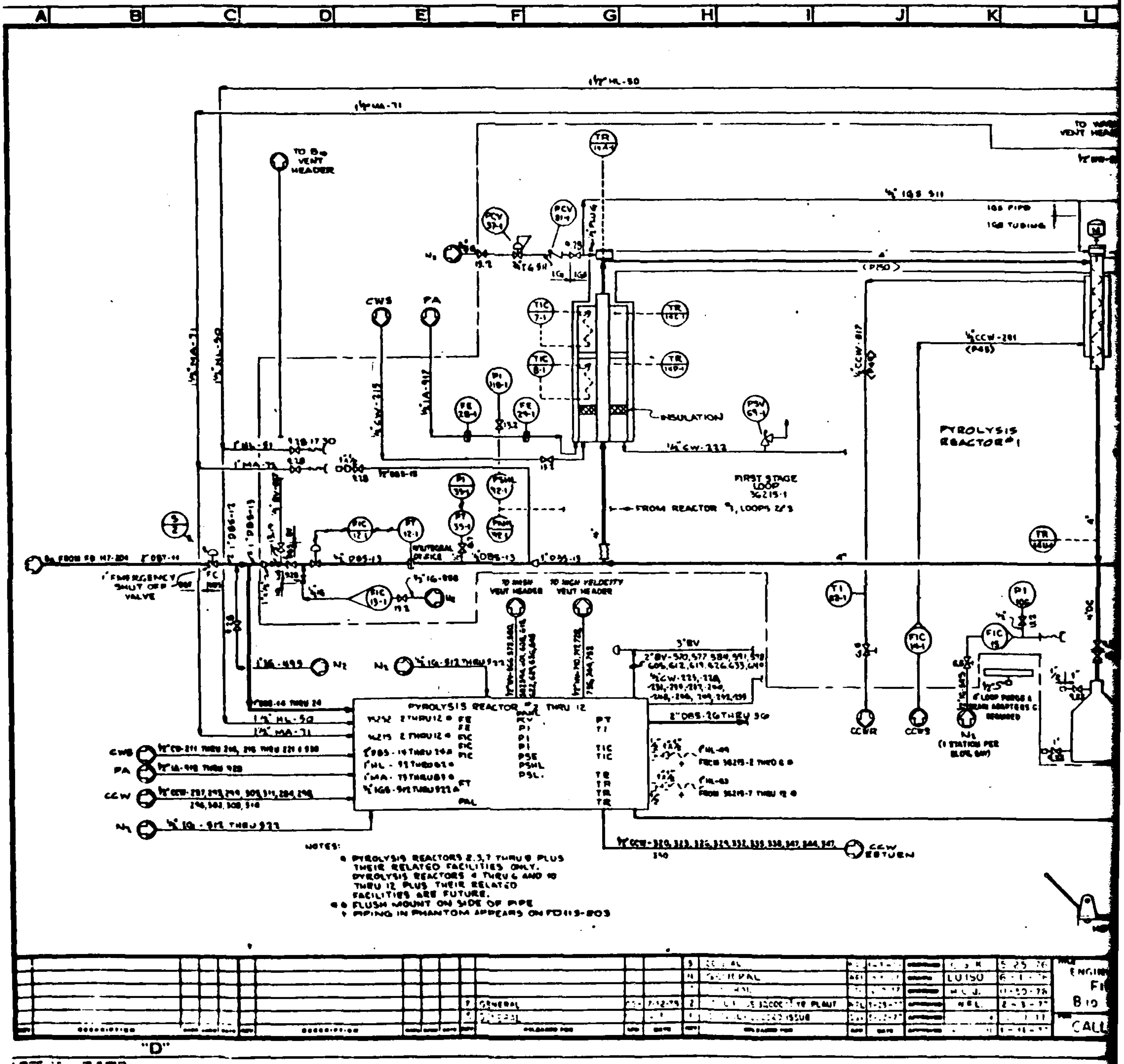
"D"



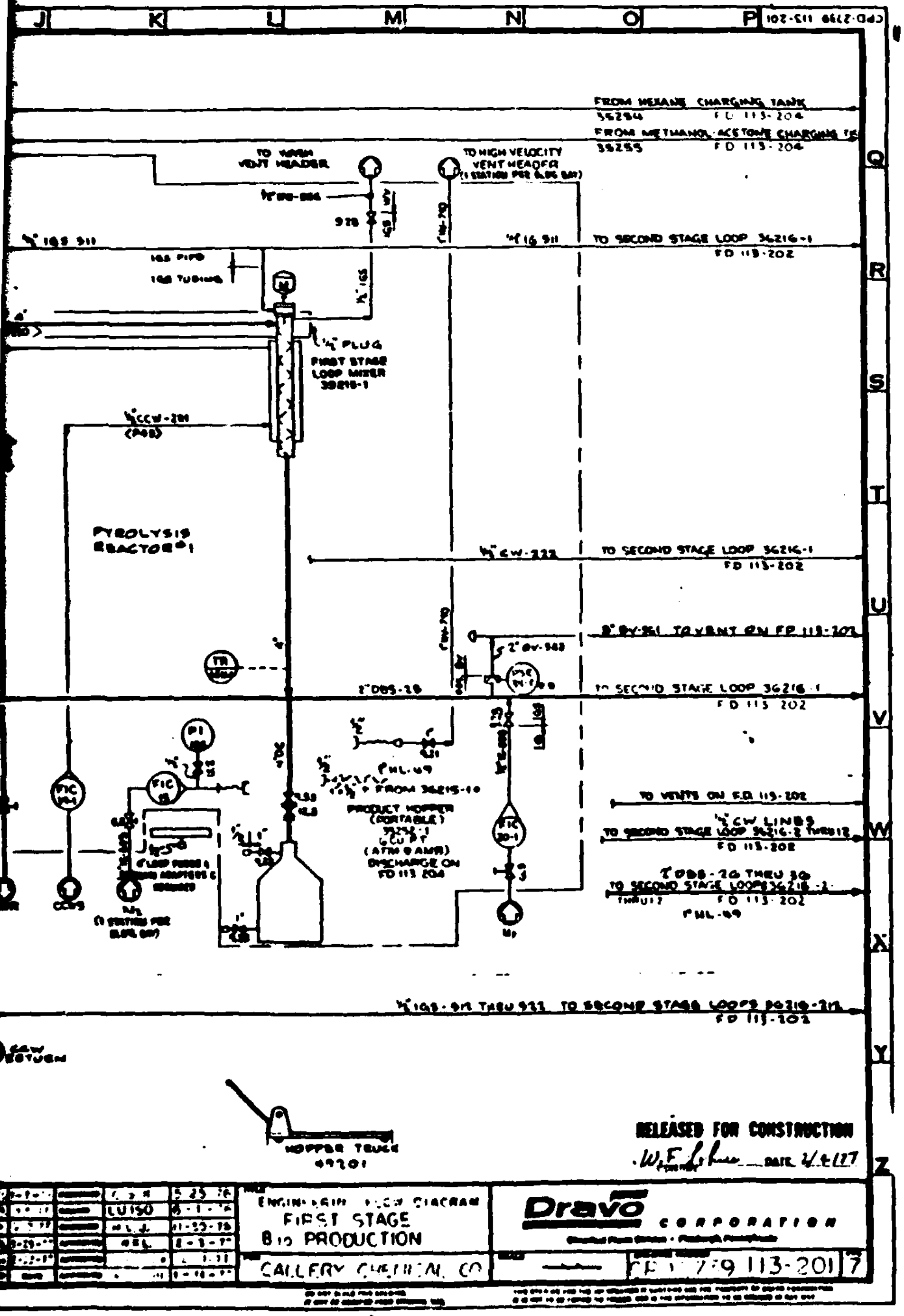
J
K
L
M
N
O
Q
R
S
T
U
V
W
X
Y
Z
TO METHANOL ACETONE TANK
TO R-1 MEASURING POT-4 35217
TO R-1 MEASURING POT-1 35208
TO R-1 MEASURING POT-3 35212
TO R-2 MEASURING POT-3 35213
TO R-2 MEASURING POT-1 35209
TO R-3 MEASURING POT 35216
TO R-4 MEASURING POT 35221
TO 1-OCTYNE MEASURING POT 35218
TO PENTANE MEASURING POT 35222
TO CAUSTIC DILUTION TANK 36209
1-OCTYNE DRUM PUMP 41211 5 GPM
CAUSTIC DRUM PUMP 41212 5 GPM
LOCATE CAUSTIC DRUM INSIDE UHC BUILDING
NOTE: THIS ITEM WAS FUTURE
RAW MATERIALS SCALE 49209
FORK TRUCK 49202
DRY ICE BOX 49203
ACETONE DRUM PUMP 41263 5 GPM
HEXANE DRUM PUMP 41201 5 GPM
TO HEXANE HOLD TANK 35241
RELEASED FOR CONSTRUCTION
ENGINEERING FLOW DIAGRAM
RAW MATERIAL
STORAGE DRUMS
CALLERY CHEMICAL CO.
Dravo
CORPORATION

-3-

2

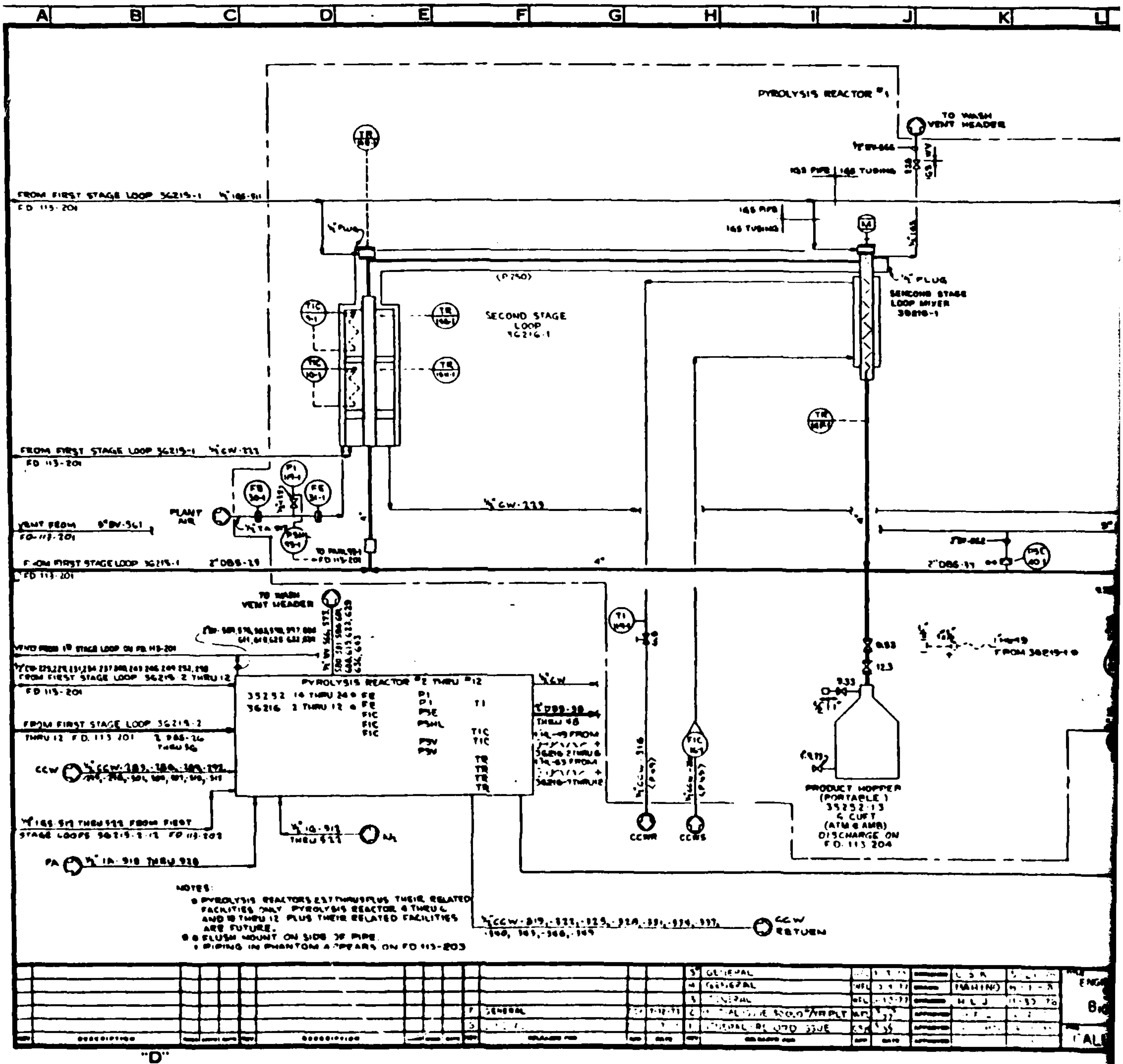


A B C D E F G H I J K L
TO B10 VENT HEADER
CWS
PA
N2
INSULATION
FIRST STAGE LOOP
FROM REACTOR #1, LOOPS 2/3
PYROLYSIS REACTOR #1
1" EMERGENCY SHUT OFF VALVE
TO HIGH VENT HEADER
TO HIGH VELOCITY VENT HEADER
PYROLYSIS REACTOR #2 THRU 12
CWS
PA
CCW
N2
CCW RETURN
NOTES:
* PYROLYSIS REACTORS 2,3,7 THRU 9 PLUS THEIR RELATED FACILITIES ONLY. PYROLYSIS REACTORS 4 THRU 6 AND 10 THRU 12 PLUS THEIR RELATED FACILITIES ARE FUTURE.
** FLUSH MOUNT ON SIDE OF PIPE
† PIPING IN PHANTOM APPEARS ON FD115-203
GENERAL
"D"



FROM HEXANE CHARGING TANK
FD 113-204
FROM METHANOL-ACETONE CHARGING TK
FD 113-204
TO WASH VENT HEADER
TO HIGH VELOCITY VENT HEADER
TO SECOND STAGE LOOP 36216-1
FD 113-202
¼" PLUG
FIRST STAGE LOOP MIXER
PYROLYSIS REACTOR #1
PRODUCT HOPPER (PORTABLE)
DISCHARGE ON FD 113-204
TO VENTS ON F.D. 113-202
TO SECOND STAGE LOOP
HOPPER TRUCK
RELEASED FOR CONSTRUCTION
ENGINEERING FLOW DIAGRAM
FIRST STAGE
B_{10} PRODUCTION
CALLERY CHEMICAL CO
Dravo
CORPORATION
113-201

2


A
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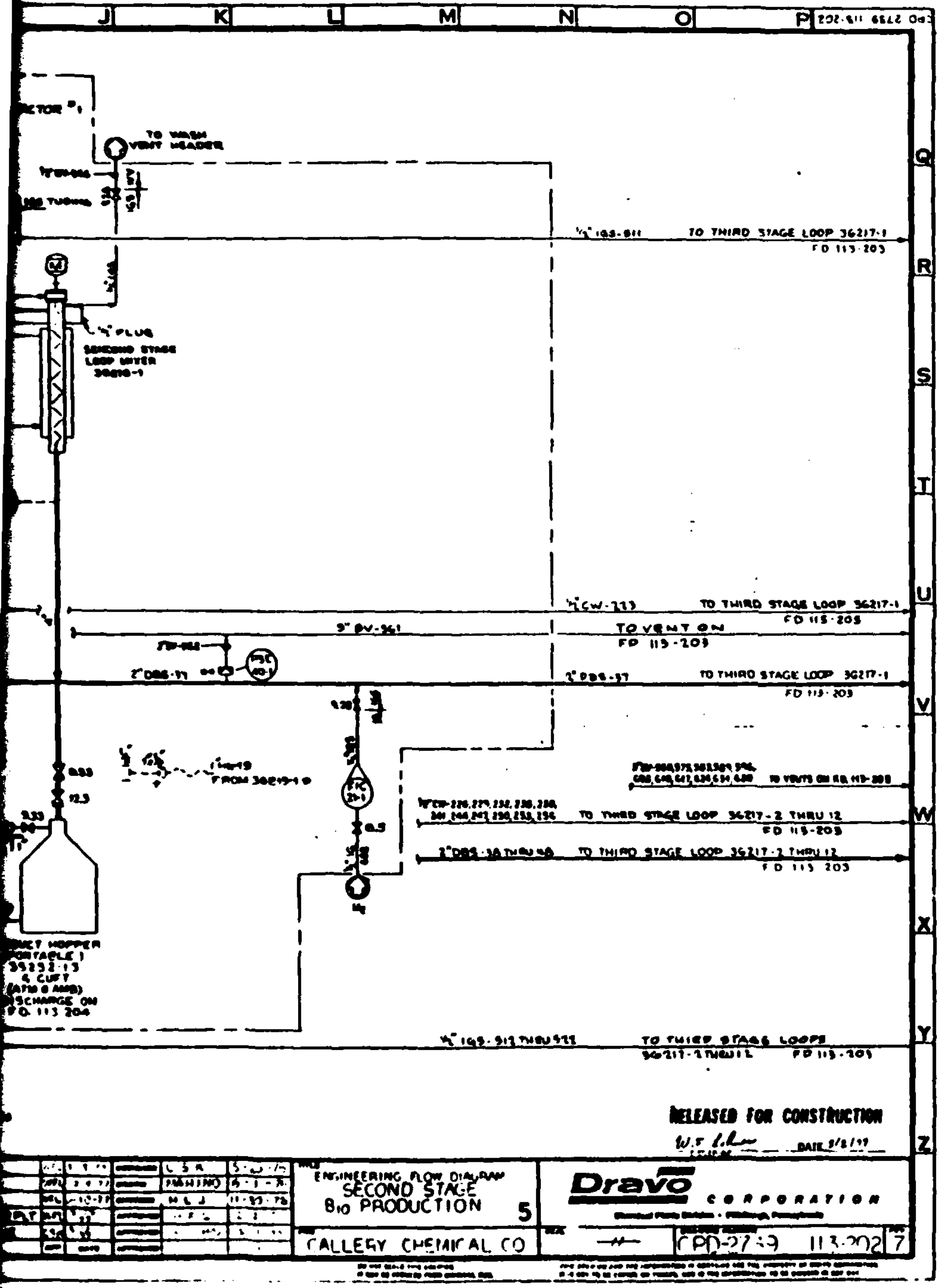
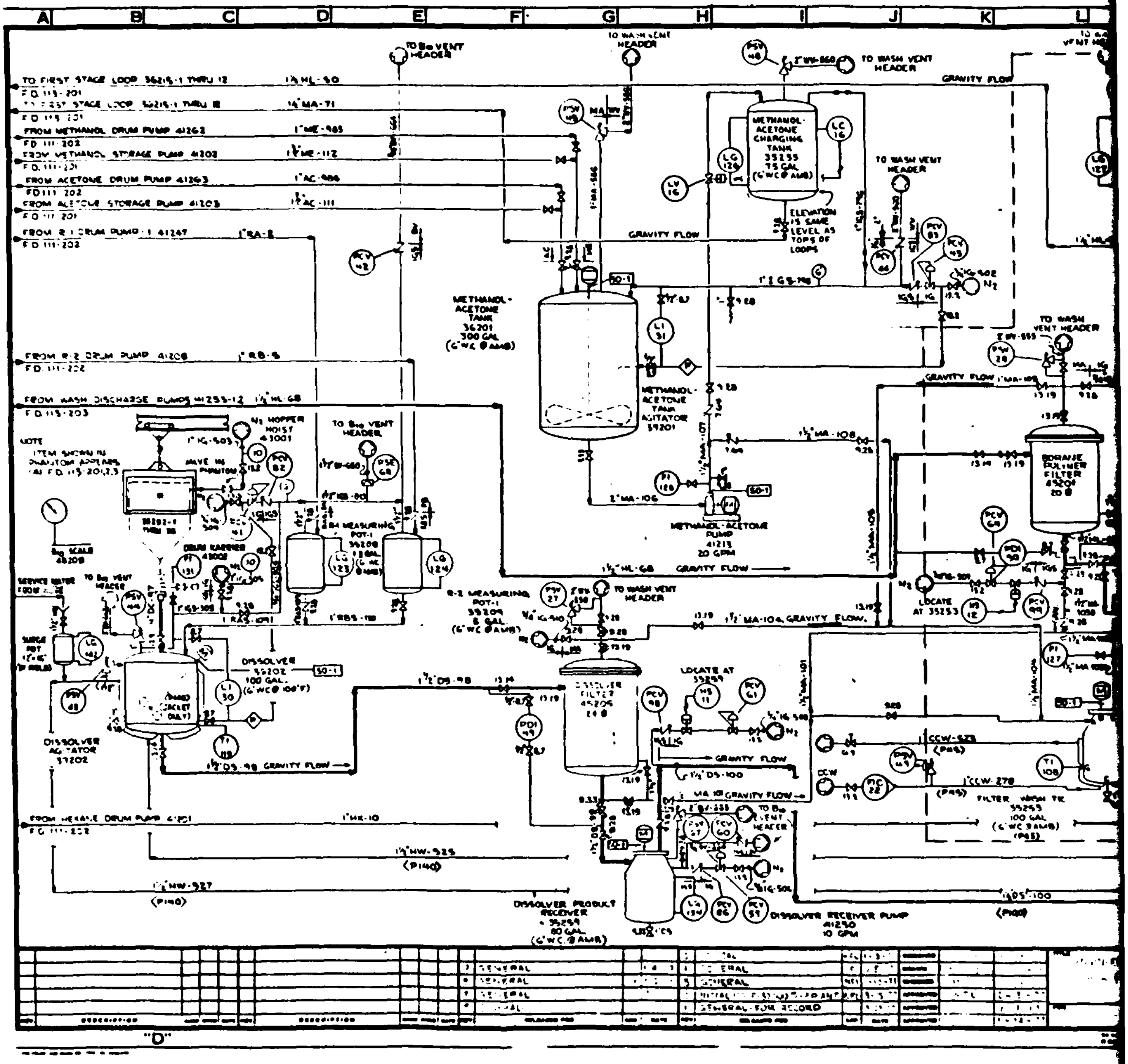
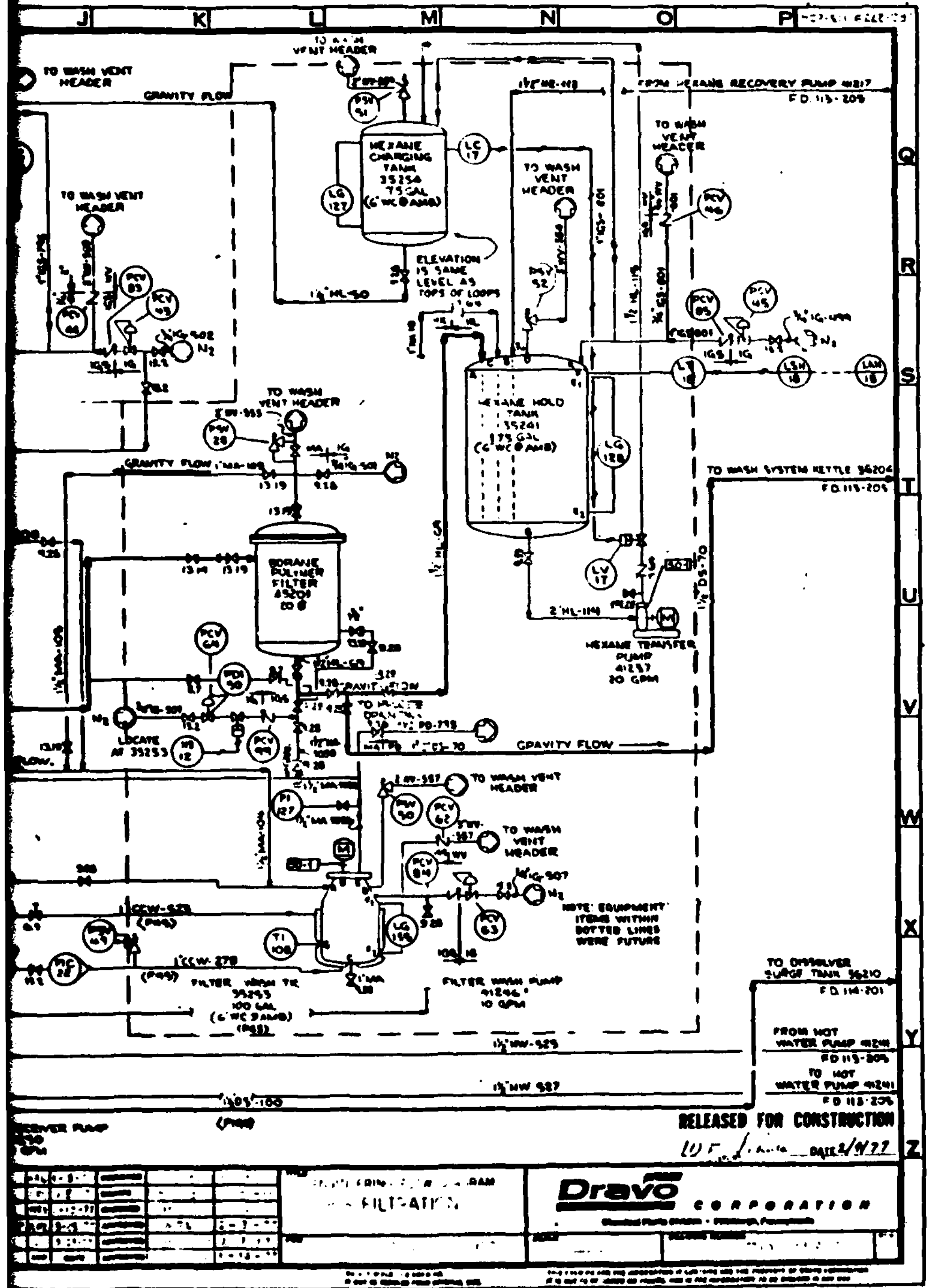
L
PYROLYSIS REACTOR #1
TO WASH VENT HEADER
FROM FIRST STAGE LOOP 36215-1
F.D. 113-201
165 PIPE
165 TUBING
(P 250)
SECOND STAGE LOOP 36216-1
SECOND STAGE LOOP MIXER 36216-1
FROM FIRST STAGE LOOP 36215-1
PLANT AIR
VENT FROM
FROM FIRST STAGE LOOP 36215-1
2" DBS-33
TO WASH VENT HEADER
FROM FIRST STAGE LOOP 36215 2 THRU 12
PYROLYSIS REACTOR #2 THRU #12
FROM FIRST STAGE LOOP 36215-2 THRU 12 F.D. 113 201
CCW
PA
CCWR
CCWS
PRODUCT HOPPER (PORTABLE) 35252-13 6 CU.FT. (ATM & AMB) DISCHARGE ON F.D. 113 204
CCW RETURN
NOTES:
PYROLYSIS REACTORS 2,3,7 THRU 9 PLUS THEIR RELATED FACILITIES ONLY. PYROLYSIS REACTOR 4 THRU 6 AND 10 THRU 12 PLUS THEIR RELATED FACILITIES ARE FUTURE.
FLUSH MOUNT ON SIDE OF PIPE.
PIPING IN PHANTOM APPEARS ON F.D. 113-203
GENERAL
"D"



TO WASH VENT HEADER
TO THIRD STAGE LOOP 36217-1
FD 113-203
SECOND STAGE LOOP MIXER
TO THIRD STAGE LOOP 36217-1
FD 115-205
TO VENT ON
FD 113-203
TO THIRD STAGE LOOP 36217-1
FD 113-203
FROM 36219-1
TO THIRD STAGE LOOP 36217-2 THRU 12
FD 115-205
TO THIRD STAGE LOOP 36217-2 THRU 12
FD 113 203
TO THIRD STAGE LOOPS
FD 113-203
RELEASED FOR CONSTRUCTION
ENGINEERING FLOW DIAGRAM
SECOND STAGE
B10 PRODUCTION
5
Dravo
CORPORATION
CALLERY CHEMICAL CO
CPD-2739 113-202 7

2


A B C D E F G H I J K L
TO FIRST STAGE LOOP 36215-1 THRU 12
FROM METHANOL DRUM PUMP 41262
FROM METHANOL STORAGE PUMP 41202
FROM ACETONE DRUM PUMP 41263
FROM ACETONE STORAGE PUMP 41203
FROM R-1 DRUM PUMP-1 41247
FROM R-2 DRUM PUMP 41208
FROM WASH DISCHARGE PUMPS 41255-12
FROM HEXANE DRUM PUMP 41201
TO WASH VENT HEADER
GRAVITY FLOW
METHANOL-ACETONE CHARGING TANK 35255 75 GAL (6" WC @ AMB)
ELEVATION IS SAME LEVEL AS TOPS OF LOOPS
METHANOL-ACETONE TANK 36201 300 GAL (6" WC @ AMB)
METHANOL-ACETONE TANK AGITATOR 35201
METHANOL-ACETONE PUMP 41213 20 GPM
N2 HOPPER HOIST 43001
DRUM CARRIER 43002
B10 SCALE 41209
SERVICE WATER
SURGE POT
DISSOLVER 35202 100 GAL (6" WC @ 100°F)
DISSOLVER AGITATOR 35202
DISSOLVER FILTER 45205
R-2 MEASURING POT-1 35209
DISSOLVER PRODUCT RECEIVER 35259 80 GAL (6" WC @ AMB)
DISSOLVER RECEIVER PUMP 41250 10 GPM
BORANE POLYMER FILTER 45201
FILTER WASH TK 35253 100 GAL (6" WC @ AMB)
LOCATE AT 35253
LOCATE AT 35259
"D"


J
K
L
M
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S
T
U
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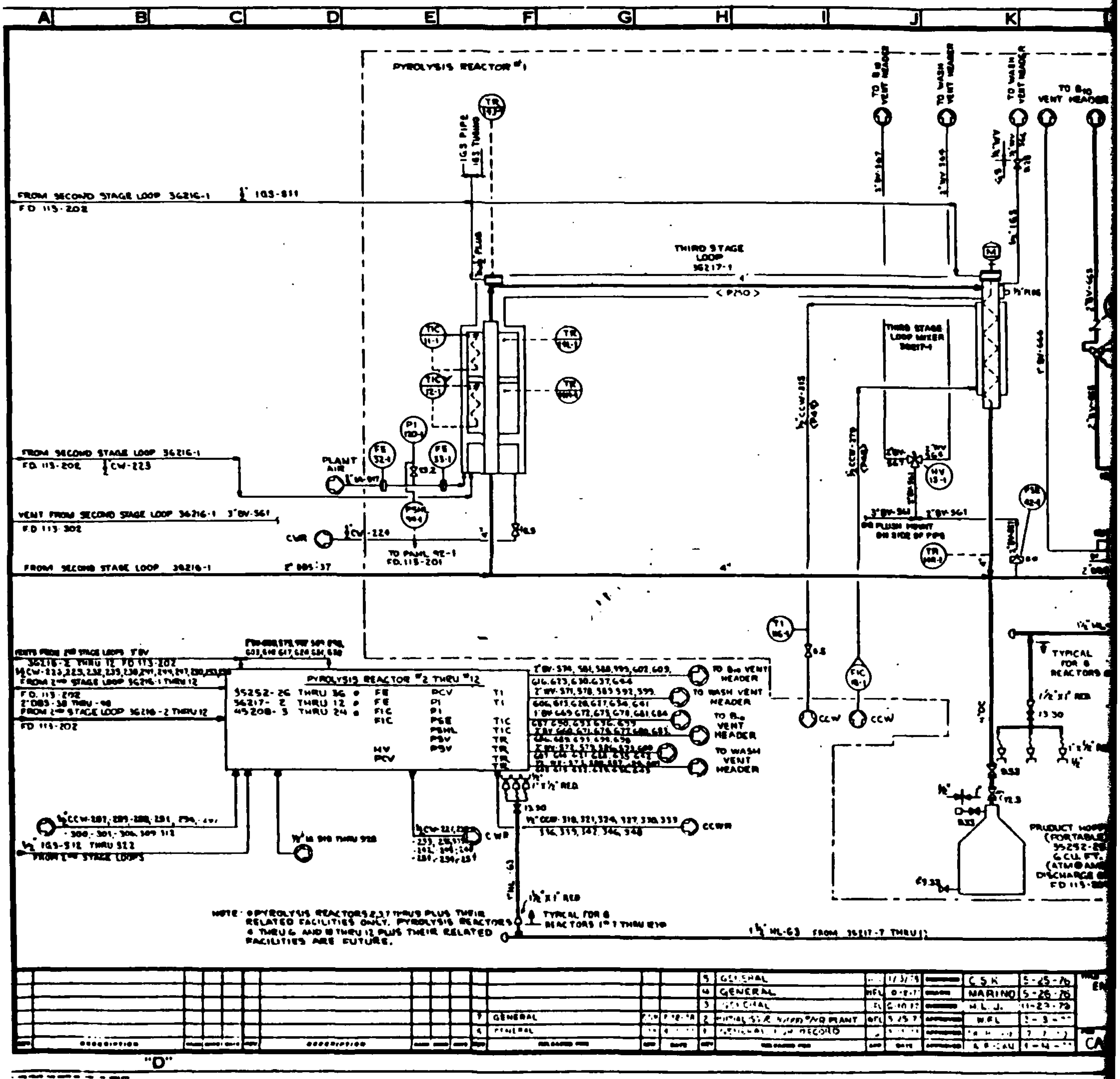
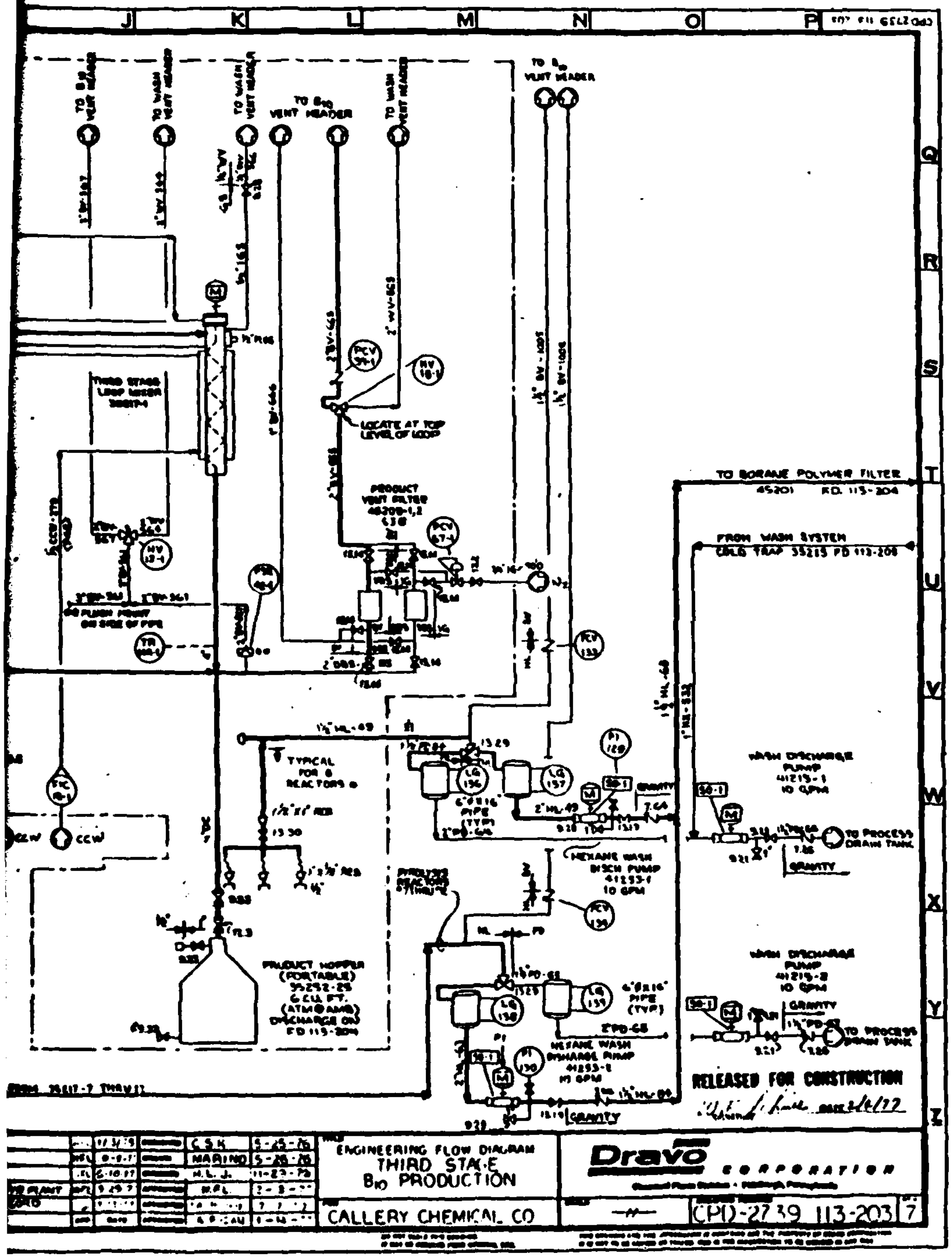
W
X
Y
Z
TO WASH VENT HEADER
GRAVITY FLOW
HEXANE CHARGING TANK 35254 75 GAL
ELEVATION IS SAME LEVEL AS TOPS OF LOOPS
FROM HEXANE RECOVERY PUMP 41217
HEXANE HOLD TANK 35241 175 GAL
BORANE POLYMER FILTER 45201
HEXANE TRANSFER PUMP 41257 30 GPM
TO WASH SYSTEM KETTLE 36204
GRAVITY FLOW
FILTER WASH TK 35253 100 GAL
FILTER WASH PUMP 41246 10 GPM
NOTE: EQUIPMENT ITEMS WITHIN DOTTED LINES WERE FUTURE
TO DISSOLVER SURGE TANK 36210
FROM HOT WATER PUMP 41241
TO HOT WATER PUMP 41241
RELEASED FOR CONSTRUCTION
FILTRATION
Dravo
CORPORATION

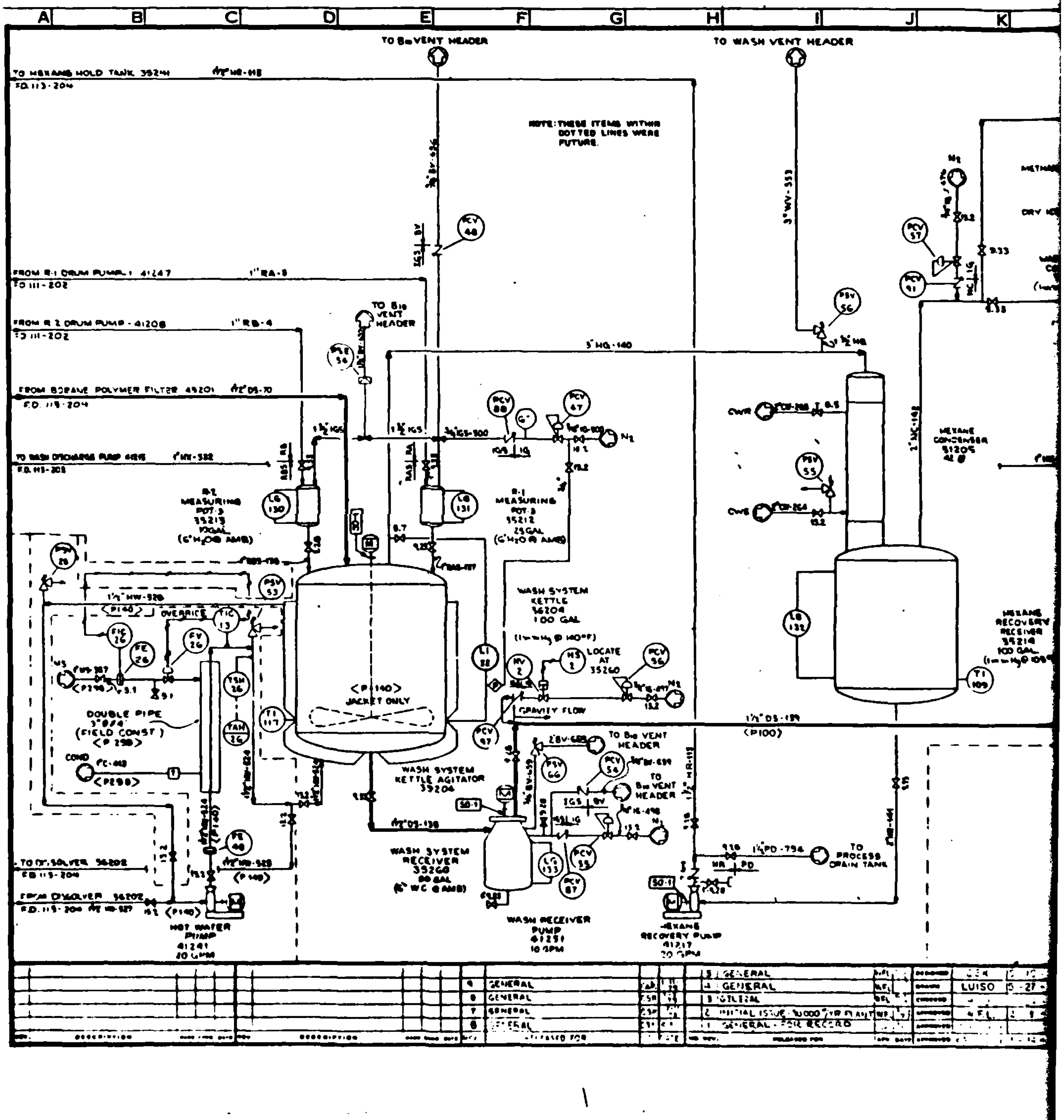
PYROLYSIS REACTOR #1
FROM SECOND STAGE LOOP 36216-1
FD 115-202
THIRD STAGE LOOP 36217-1
THIRD STAGE LOOP MIXER
PLANT AIR
CWR
TO B10 VENT HEADER
TO WASH VENT HEADER
VENT FROM SECOND STAGE LOOP 36216-1
FROM SECOND STAGE LOOP 36216-1
PYROLYSIS REACTOR #2 THRU #12
35252-26 THRU 36
36217-2 THRU 12
45208-3 THRU 24
FE
FIC
HV
PCV
PI
PSE
PSHL
PSV
TI
TIC
TR
CCW
CCWR
CWR
TYPICAL FOR 6 REACTORS
PRODUCT HOPPER (PORTABLE)
NOTE: PYROLYSIS REACTORS 2,3,7 THRU 9 PLUS THEIR RELATED FACILITIES ONLY. PYROLYSIS REACTORS 4 THRU 6 AND 10 THRU 12 PLUS THEIR RELATED FACILITIES ARE FUTURE.
GENERAL
"D"

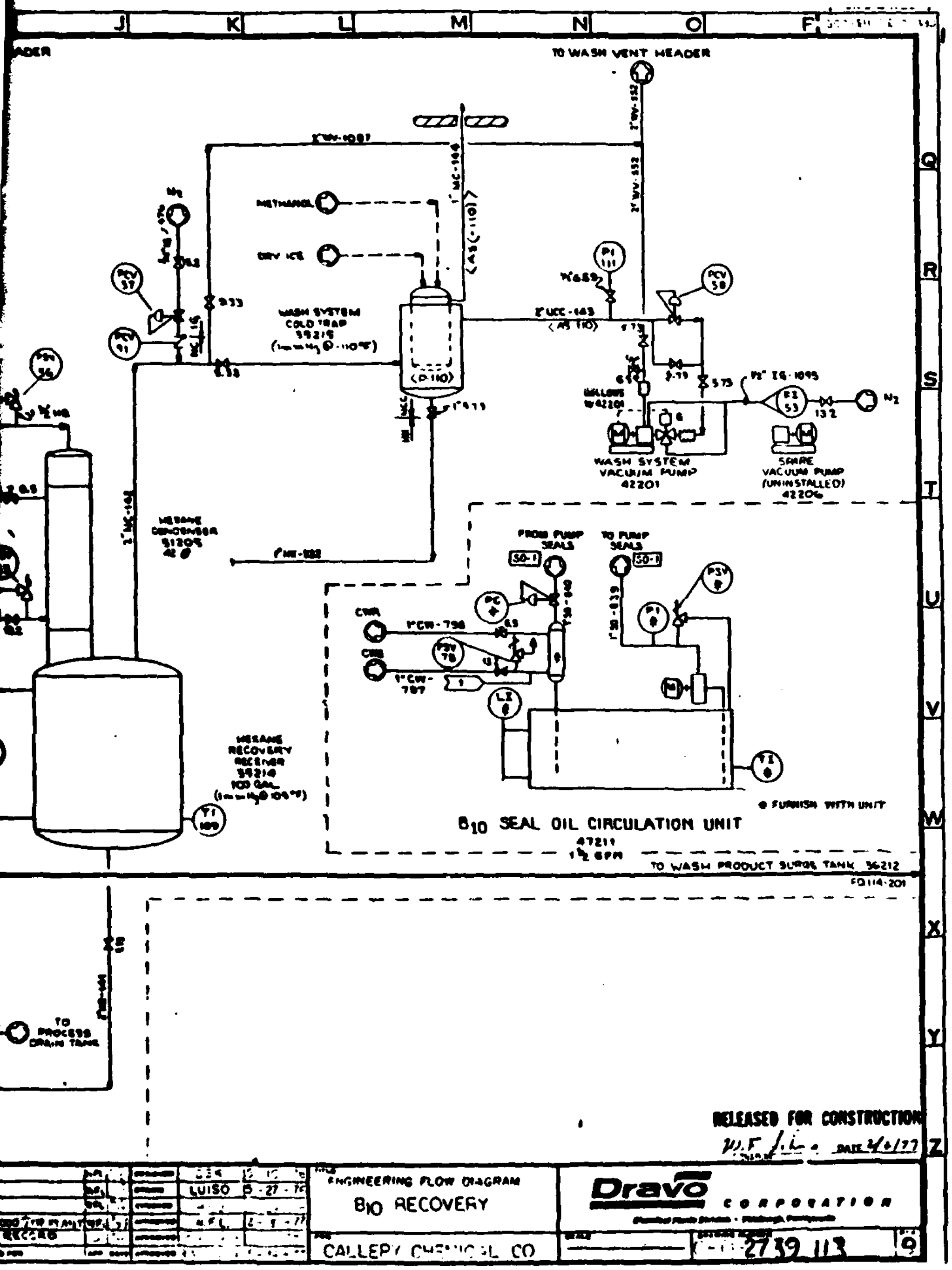


TO B_{10} VENT HEADER
TO WASH VENT HEADER
THIRD STAGE LOOP MIXER
LOCATE AT TOP LEVEL OF LOOP
PRODUCT VENT FILTER
TO BORANE POLYMER FILTER 45201 FD. 113-204
FROM WASH SYSTEM COLD TRAP 35215 FD 113-206
TYPICAL FOR 6 REACTORS
WASH DISCHARGE PUMP 41215-1 10 GPM
TO PROCESS DRAIN TANK
GRAVITY
HEXANE WASH DISCH PUMP 41253-1 10 GPM
PRODUCT HOPPER (PORTABLE)
WASH DISCHARGE PUMP 41215-2 10 GPM
HEXANE WASH DISCHARGE PUMP 41253-2 10 GPM
RELEASED FOR CONSTRUCTION
ENGINEERING FLOW DIAGRAM
THIRD STAGE
B_{10} PRODUCTION
CALLERY CHEMICAL CO
Dravo CORPORATION
CPD-2739 113-203 7

2

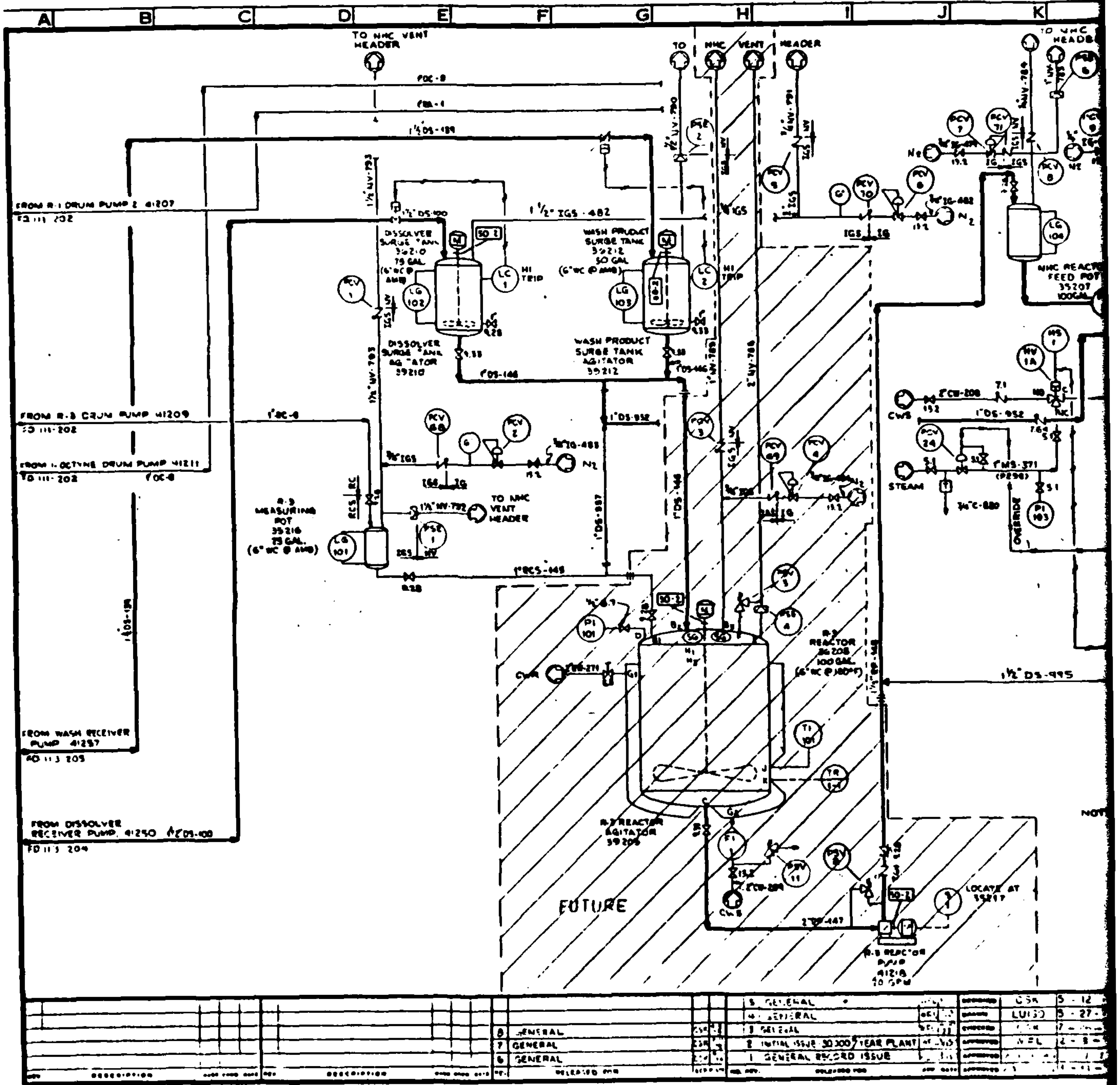
2


TO WASH VENT HEADER
NOTE: THESE ITEMS WITHIN DOTTED LINES WERE FUTURE.
FROM R-1 DRUM PUMP-1 41247
FROM R-2 DRUM PUMP - 41208
FROM BORANE POLYMER FILTER 49201
R-2 MEASURING POT-3 35213
R-1 MEASURING POT-3 35212
WASH SYSTEM KETTLE 35204 100 GAL
JACKET ONLY
DOUBLE PIPE
(FIELD CONST)
GRAVITY FLOW
WASH SYSTEM KETTLE AGITATOR 35206
WASH SYSTEM RECEIVER 35260 80 GAL
HOT WATER PUMP 41241 20 GPM
WASH RECEIVER PUMP 41251 10 GPM
HEXANE RECOVERY PUMP 41217 20 GPM
HEXANE CONDENSER 51205
HEXANE RECOVERY RECEIVER 35214 100 GAL
TO PROCESS DRAIN TANK
GENERAL
INITIAL ISSUE
LUISO



TO WASH VENT HEADER
METHANOL
DRY ICE
WASH SYSTEM COLD TRAP 39219
WASH SYSTEM VACUUM PUMP 42201
SPARE VACUUM PUMP (UNINSTALLED) 42206
HEXANE CONDENSER 91209
HEXANE RECOVERY RECEIVER 39218 100 GAL.
FROM PUMP SEALS
TO PUMP SEALS
B10 SEAL OIL CIRCULATION UNIT
47211
1½ GPM
● FURNISH WITH UNIT
TO WASH PRODUCT SURGE TANK 36212
TO PROCESS DRAIN TANK
RELEASED FOR CONSTRUCTION
ENGINEERING FLOW DIAGRAM
B10 RECOVERY
CALLERY CHEMICAL CO
Dravo CORPORATION
2739 113
9

2


A
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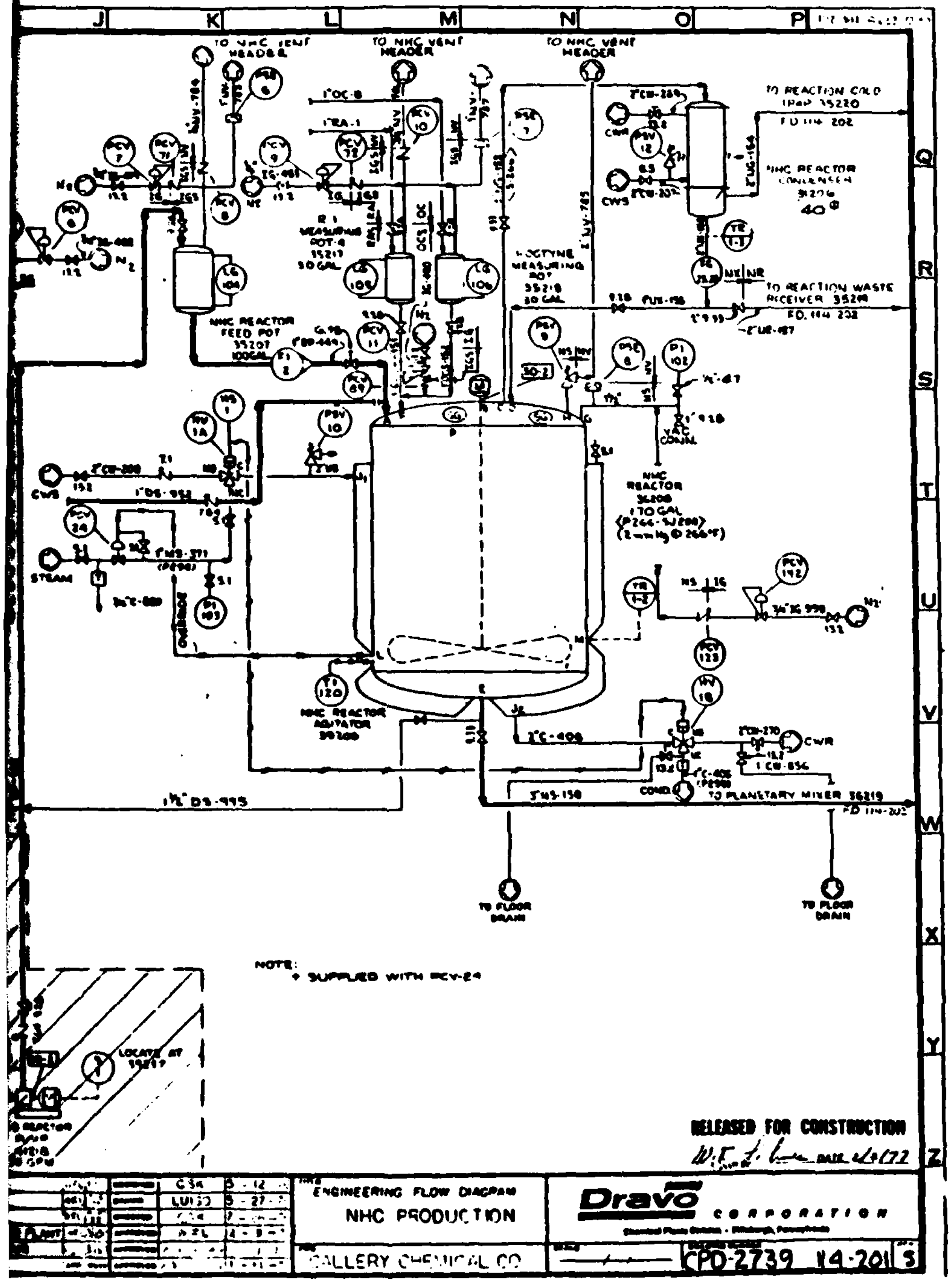
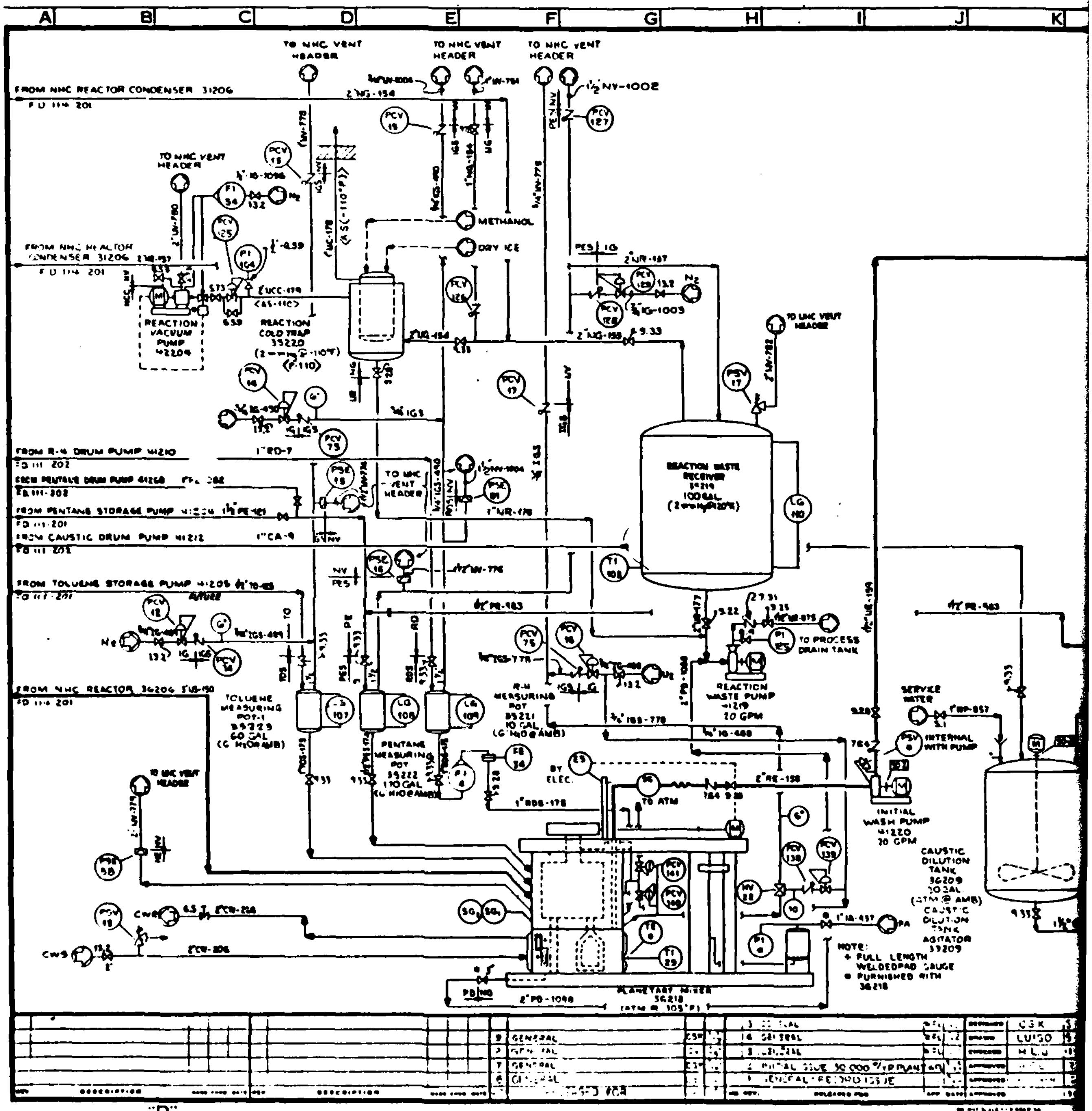
K
TO NHC VENT HEADER
TO NHC VENT HEADER
FROM R-1 DRUM PUMP 2 41207
FROM R-3 DRUM PUMP 41209
FROM 1-OCTYNE DRUM PUMP 41211
FROM WASH RECEIVER PUMP 41257
FROM DISSOLVER RECEIVER PUMP 41250
1 1/2" IGS - 482
DISSOLVER SURGE TANK
DISSOLVER SURGE TANK AGITATOR 35210
WASH PRODUCT SURGE TANK 35212 50 GAL
WASH PRODUCT SURGE TANK AGITATOR 35212
HI TRIP
R-3 MEASURING POT 35216 25 GAL. (6" WC @ AMB)
R-3 REACTOR 36208 100 GAL.
R-3 REACTOR AGITATOR 39209
R-3 REACTOR PUMP 41218 10 GPM
LOCATE AT 35217
NHC REACTOR FEED POT 35207 100GAL
CWS
CWR
STEAM
OVERRIDE
1 1/2" DS-995
FUTURE
8 GENERAL
7 GENERAL
6 GENERAL
5 GENERAL
4 GENERAL
3 GENERAL
2 INITIAL ISSUE 30,000 YEAR PLANT
1 GENERAL RECORD ISSUE
DESCRIPTION
RELEASED FOR

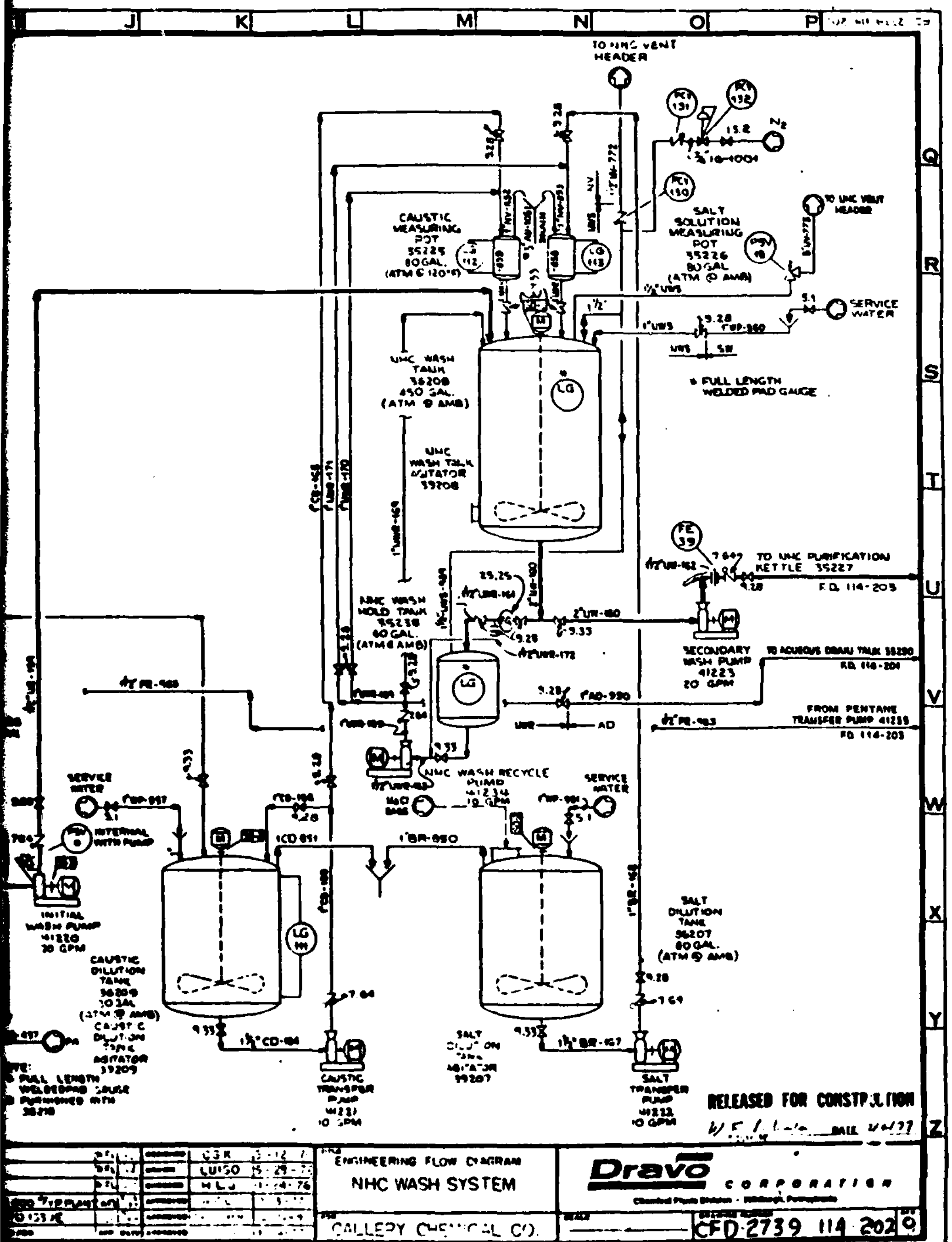

TO NHC VENT HEADER
TO NHC VENT HEADER
TO NHC VENT HEADER
TO REACTION COLD TRAP 35220
NHC REACTOR CONDENSER 35216
NHC REACTOR FEED POT 35207 100 GAL
R 1 MEASURING POT 4 35217 30 GAL
OCTYNE MEASURING POT 35218 30 GAL
TO REACTION WASTE RECEIVER 35219
NHC REACTOR 35208 1 TO GAL
VAC CONN
NHC REACTOR AGITATOR 35208
TO PLANETARY MIXER 36219
TO FLOOR DRAIN
TO FLOOR DRAIN
CWS
CWR
STEAM
COND.
NOTE:
* SUPPLIED WITH PCV-24
LOCATE AT 35217
RELEASED FOR CONSTRUCTION
ENGINEERING FLOW DIAGRAM
NHC PRODUCTION
CALLERY CHEMICAL CO
Dravo CORPORATION
CPD-2739 14-201 3

9

2

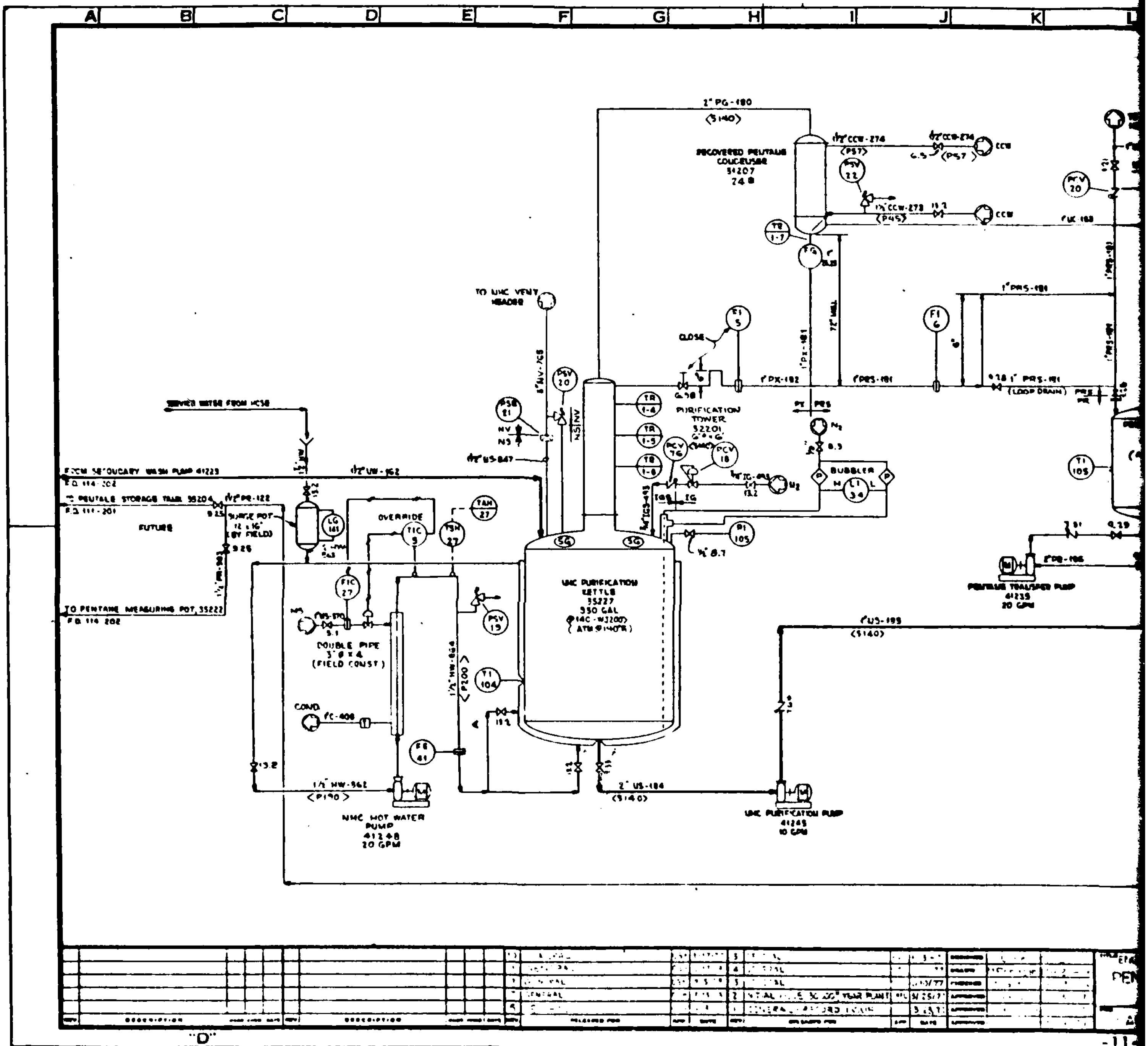
1


TO NHC VENT HEADER
FROM NHC REACTOR CONDENSER 31206
METHANOL
DRY ICE
REACTION VACUUM PUMP 42204
REACTION COLD TRAP 35220
FROM R-4 DRUM PUMP 41210
FROM PENTANE STORAGE PUMP
FROM CAUSTIC DRUM PUMP 41212
FROM TOLUENE STORAGE PUMP 41205
FROM NHC REACTOR 36206
REACTION WASTE RECEIVER 35219 100 GAL.
TO PROCESS DRAIN TANK
REACTION WASTE PUMP 41219 20 GPM
TOLUENE MEASURING POT-1 35223 60 GAL
PENTANE MEASURING POT 35222 110 GAL
R-4 MEASURING POT 35221 10 GAL
SERVICE WATER
INTERNAL WITH PUMP
INITIAL WASH PUMP 41220 30 GPM
CAUSTIC DILUTION TANK 36209
CAUSTIC DILUTION TANK AGITATOR 33209
BY ELEC.
TO ATM
PLANETARY MIXER 36218
NOTE:
FULL LENGTH WELDEDPAD GAUGE
FURNISHED WITH 36218
GENERAL
"D"



TO NHC VENT HEADER
CAUSTIC MEASURING POT 35225 80 GAL. (ATM @ 120°F)
SALT SOLUTION MEASURING POT 35226 80 GAL. (ATM @ AMB)
SERVICE WATER
NHC WASH TANK 35208 450 GAL. (ATM @ AMB)
* FULL LENGTH WELDED PAD GAUGE
NHC WASH TANK AGITATOR 35208
TO NHC PURIFICATION KETTLE 35227
F.D. 114-205
NHC WASH HOLD TANK 35238 60 GAL. (ATM @ AMB)
SECONDARY WASH PUMP 41225 20 GPM
TO AQUEOUS DRAIN TANK 35290
FROM PENTANE TRANSFER PUMP 41255
F.D. 114-203
NHC WASH RECYCLE PUMP 41234 10 GPM
INITIAL WASH PUMP 41220 20 GPM
CAUSTIC DILUTION TANK 35209
SALT DILUTION TANK 35207 80 GAL. (ATM @ AMB)
CAUSTIC TRANSFER PUMP 41231 10 GPM
SALT TRANSFER PUMP 41232 10 GPM
RELEASED FOR CONSTRUCTION
ENGINEERING FLOW DIAGRAM
NHC WASH SYSTEM
Dravo CORPORATION
CALLERY CHEMICAL CO.
CFD 2739 114 202 0

2


A
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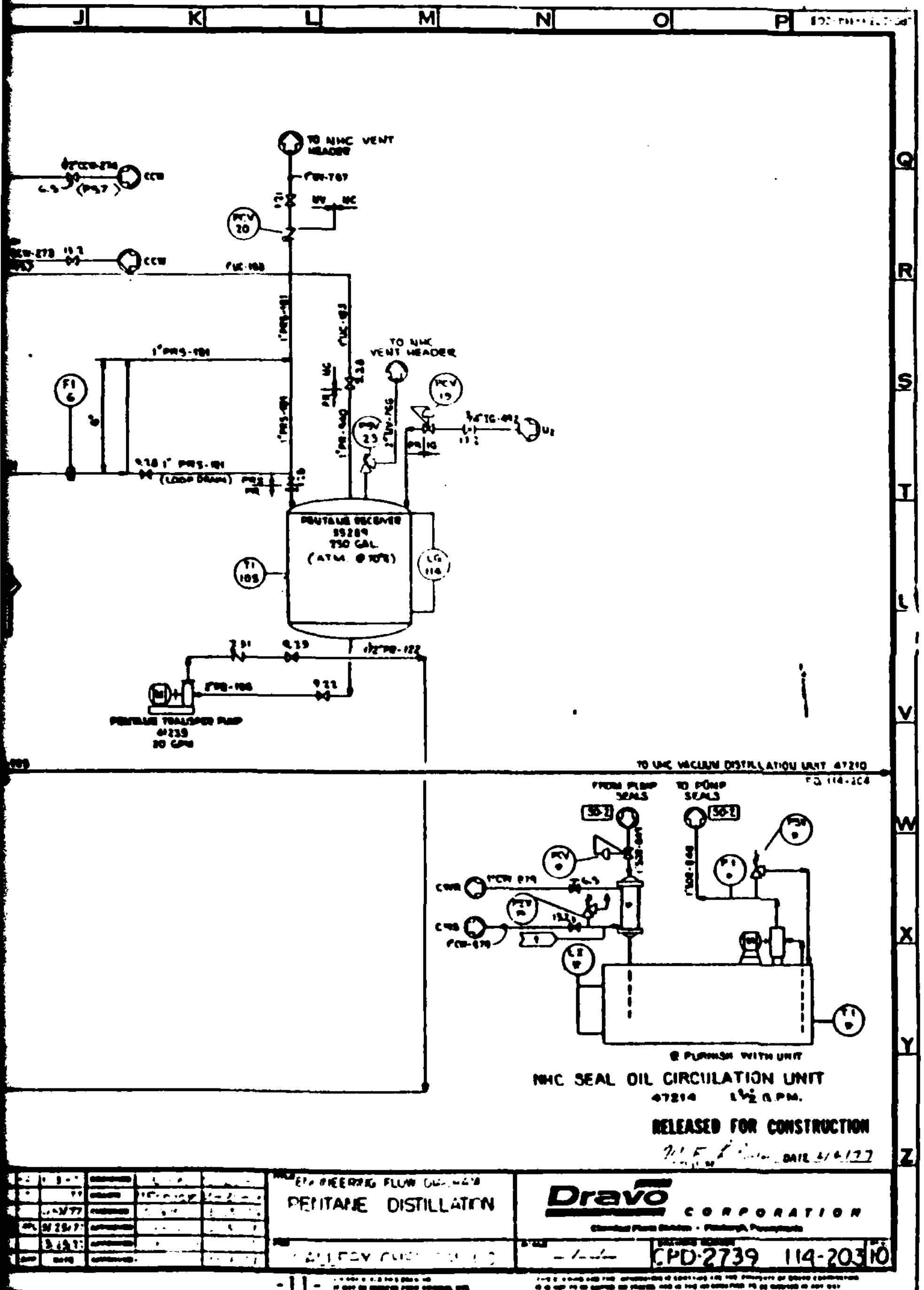
L
2" PG-180
TO UMC VENT HEADER
PURIFICATION TOWER
32201
FROM SECONDARY WASH PUMP 41223
OVERRIDE
FUTURE
SURGE POT
TO PENTANE MEASURING POT 35222
UMC PURIFICATION KETTLE
35227
350 GAL
DOUBLE PIPE
(FIELD CONST)
COND.
NMC HOT WATER PUMP
41248
20 GPM
2" US-184
UMC PURIFICATION PUMP
41245
10 GPM
BUBBLER
CLOSE
"D"



J
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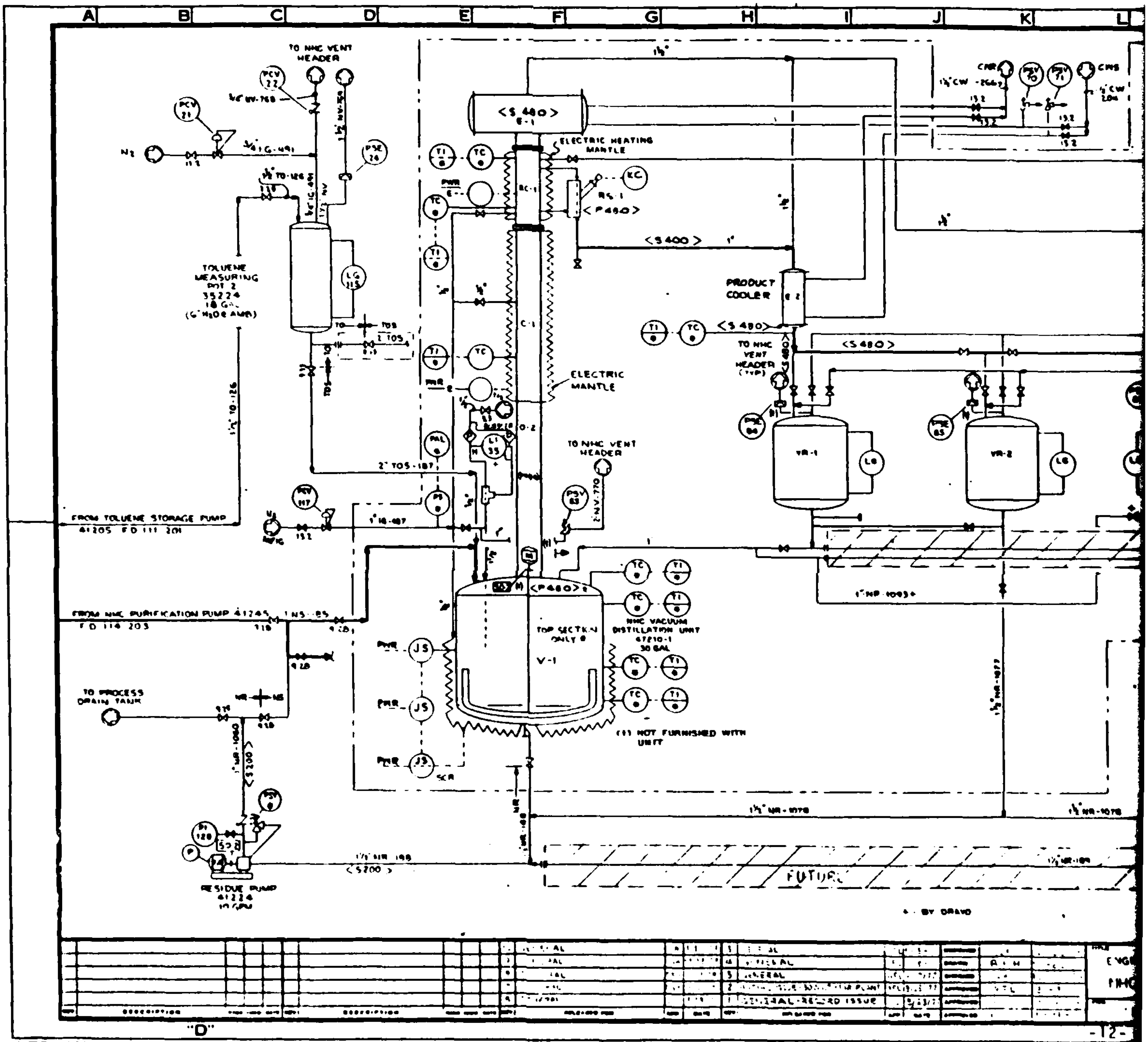
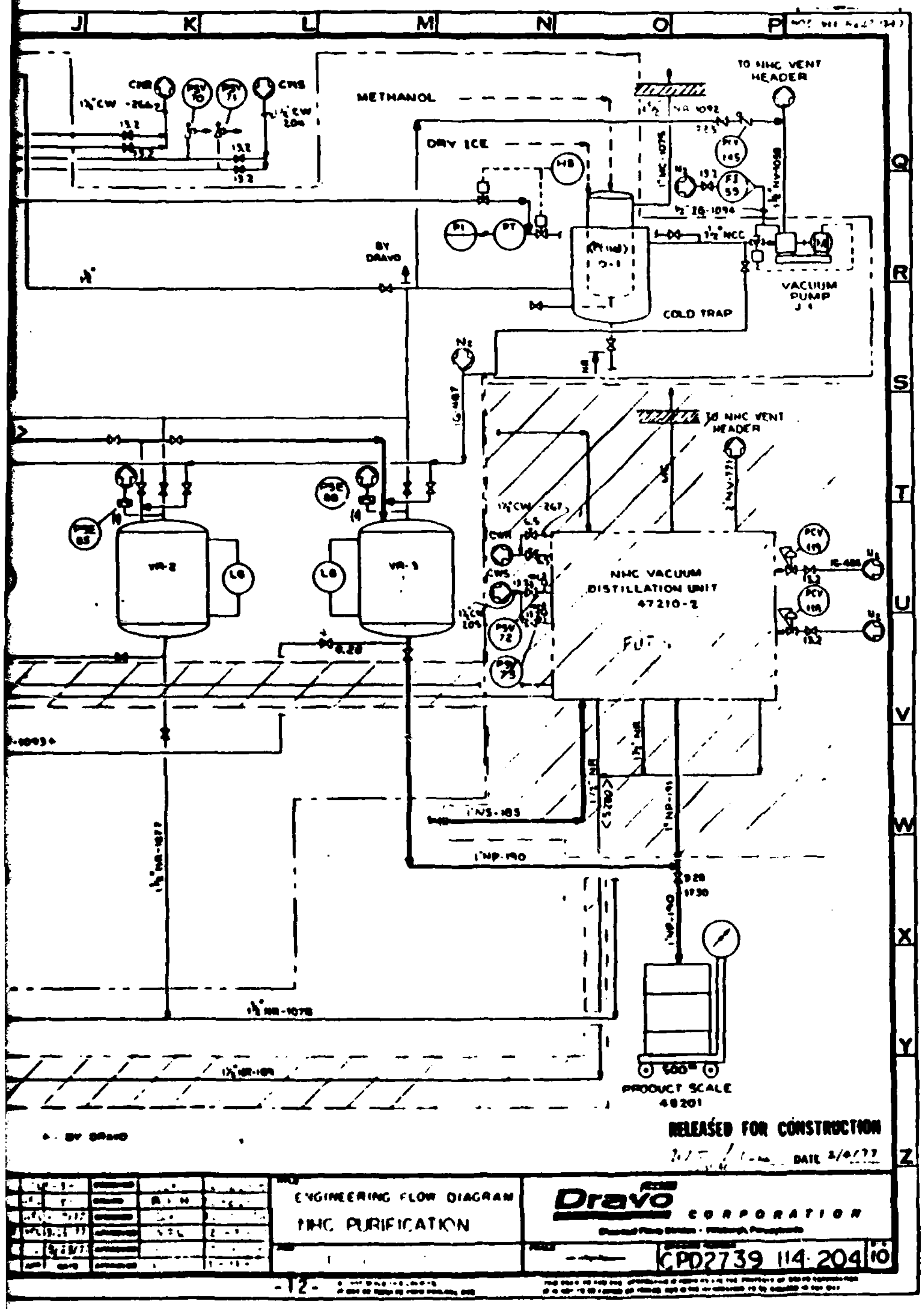
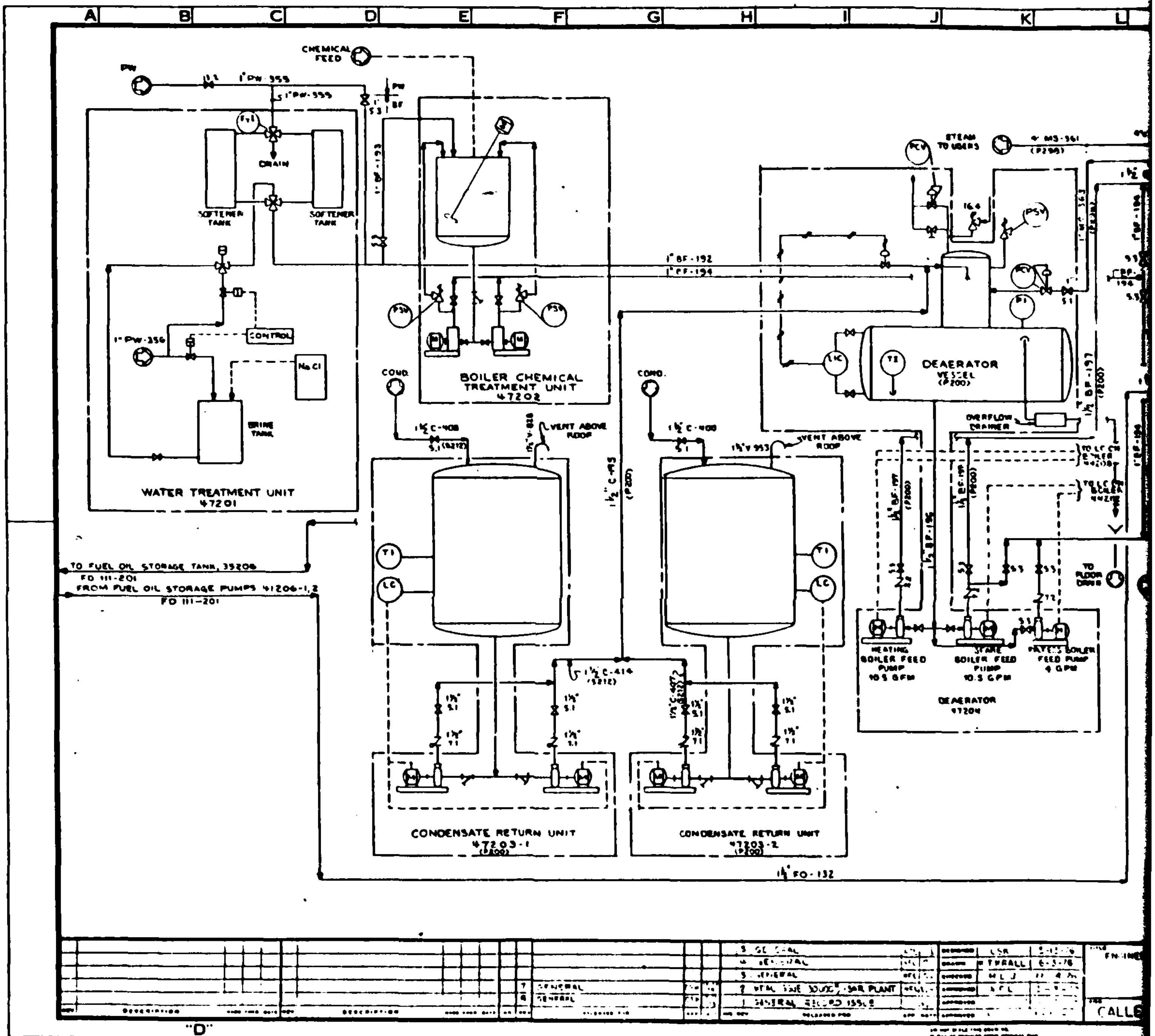
X
Y
Z
TO NHC VENT HEADER
CCW
PCV 20
TO NHC VENT HEADER
PCV 19
FI 6
PSV 23
PENTANE RECEIVER 35289 250 GAL (ATM. @ 100°F)
TI 105
LG 116
PENTANE TRANSFER PUMP 41235 30 GPM
TO NHC VACUUM DISTILLATION UNIT 47210
FROM PUMP SEALS
TO PUMP SEALS
CWR
CWS
NHC SEAL OIL CIRCULATION UNIT
47214
RELEASED FOR CONSTRUCTION
PENTANE DISTILLATION
Dravo CORPORATION
CPD-2739
114-203
10



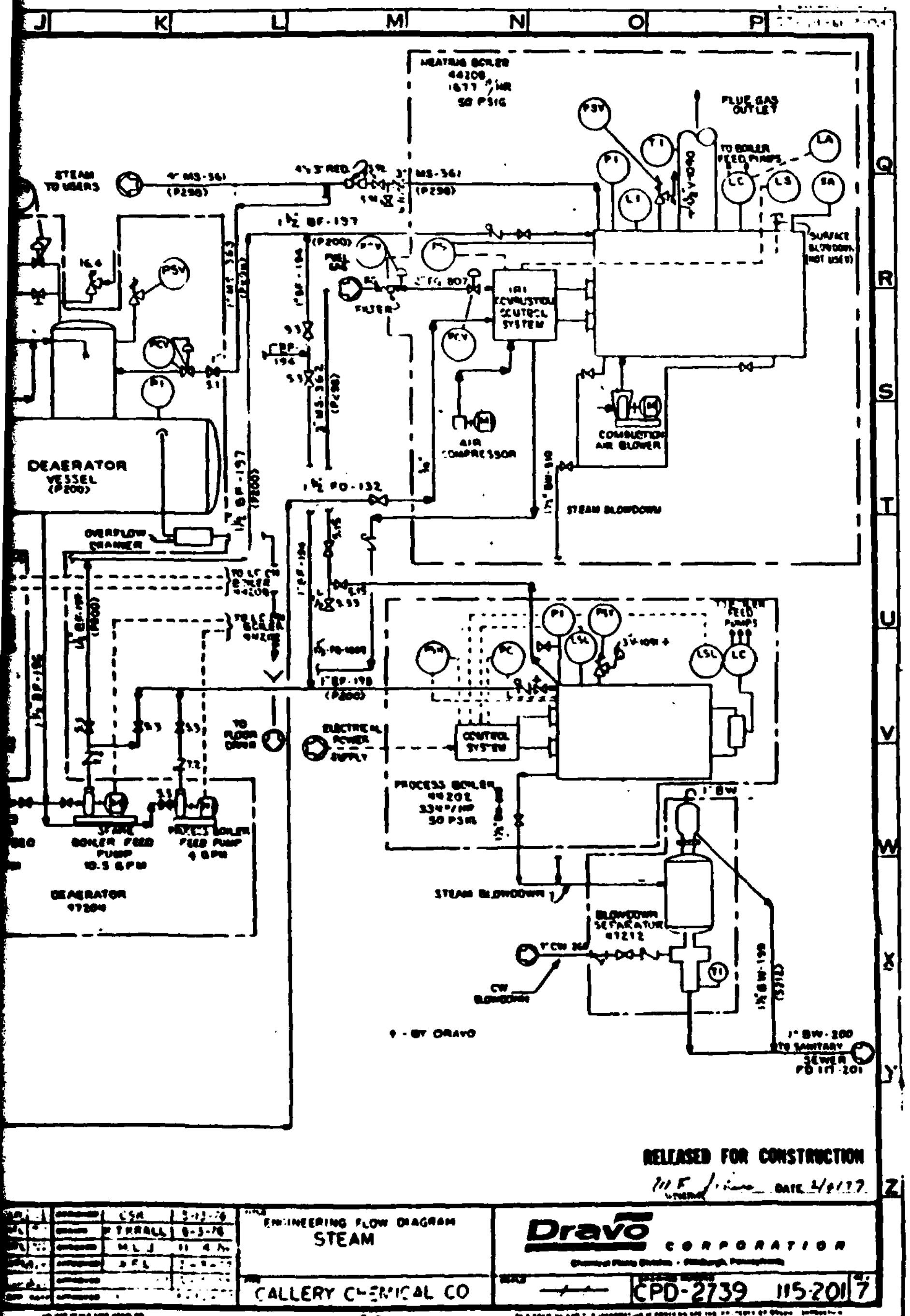
TO NHC VENT HEADER
TOLUENE MEASURING POT 2
35224
18 GAL
FROM TOLUENE STORAGE PUMP
41205 F.D. 111 201
FROM NHC PURIFICATION PUMP 41245
F.D. 114 203
TO PROCESS DRAIN TANK
RESIDUE PUMP
41234
<S 480>
E-1
ELECTRIC HEATING MANTLE
<P480>
<S400>
ELECTRIC MANTLE
TO NHC VENT HEADER
TOP SECTION ONLY
V-1
NHC VACUUM DISTILLATION UNIT
47210-1
30 GAL
(1) NOT FURNISHED WITH UNIT
PRODUCT COOLER
<S 480>
TO NHC VENT HEADER (TYP)
VR-1
VR-2
FUTURE
BY DRAVO
GENERAL RECORD ISSUE
DESCRIPTION
"D"
-12-



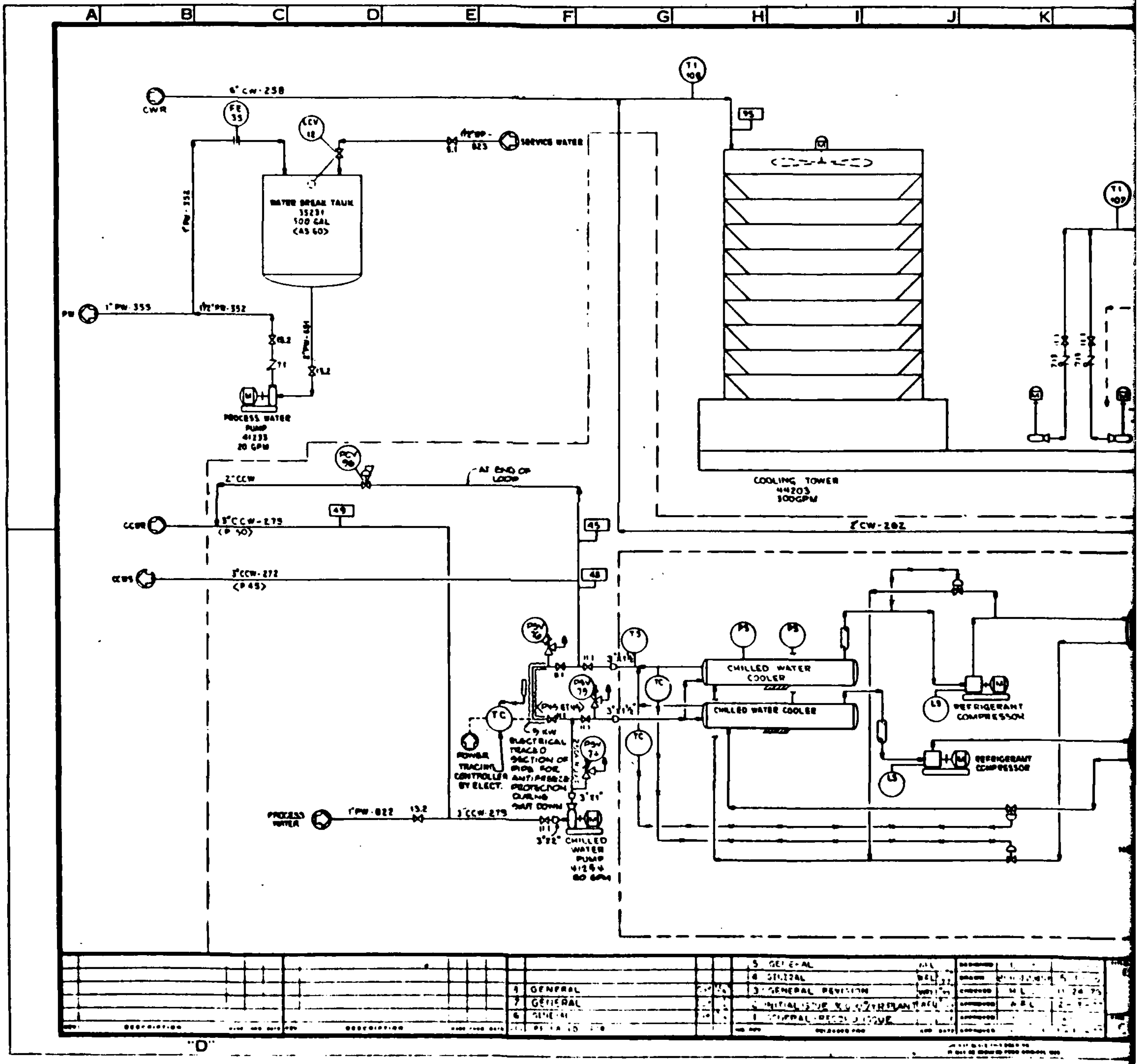
METHANOL
DRY ICE
COLD TRAP
VACUUM PUMP
TO NHC VENT HEADER
NHC VACUUM DISTILLATION UNIT 47210-2
VR-2
VR-3
PRODUCT SCALE 48201
RELEASED FOR CONSTRUCTION
ENGINEERING FLOW DIAGRAM
NHC PURIFICATION
Dravo CORPORATION
CPD2739 114-204



CHEMICAL FEED
PW
1" PW-355
1" BF-192
1" BF-193
1" BF-194
SOFTENER TANK
DRAIN
CONTROL
1" PW-356
NaCl
BRINE TANK
WATER TREATMENT UNIT
47201
BOILER CHEMICAL TREATMENT UNIT
47202
COND.
VENT ABOVE ROOF
STEAM TO USERS
DEAERATOR VESSEL (P200)
OVERFLOW DRAINER
HEATING BOILER FEED PUMP 10.5 GPM
SPARE BOILER FEED PUMP 10.5 GPM
DEAERATOR
47204
TO FLOOR DRAIN
TO FUEL OIL STORAGE TANK, 35206
FO 111-201
FROM FUEL OIL STORAGE PUMPS 41206-1,2
FO 111-201
CONDENSATE RETURN UNIT
47203-1
(P200)
CONDENSATE RETURN UNIT
47203-2
(P200)
1½" FO-132
"D"


STEAM TO USERS
4" MS-361 (P290)
3" MS-361 (P290)
1½" BF-197
DEAERATOR VESSEL (P200)
OVERFLOW DRAINER
HEATING BOILER 44208
50 PSIG
FLUE GAS OUTLET
TO BOILER FEED PUMPS
SURFACE BLOWDOWN (NOT USED)
FUEL GAS
FILTER
COMBUSTION CONTROL SYSTEM
AIR COMPRESSOR
COMBUSTION AIR BLOWER
STEAM BLOWDOWN
1½" FO-132
1" BF-198 (P200)
TO FLOOR DRAIN
ELECTRICAL POWER SUPPLY
CONTROL SYSTEM
PROCESS BOILER 44202
50 PSIG
SPARE BOILER FEED PUMP 10.5 GPM
PROCESS BOILER FEED PUMP 4 GPM
DEAERATOR
BLOWDOWN SEPARATOR
CW BLOWDOWN
1" BW-200
TO SANITARY SEWER
· - BY DRAVO
RELEASED FOR CONSTRUCTION
ENGINEERING FLOW DIAGRAM
STEAM
CALLERY CHEMICAL CO
Dravo CORPORATION
CPD-2739
115-201
7

2


A
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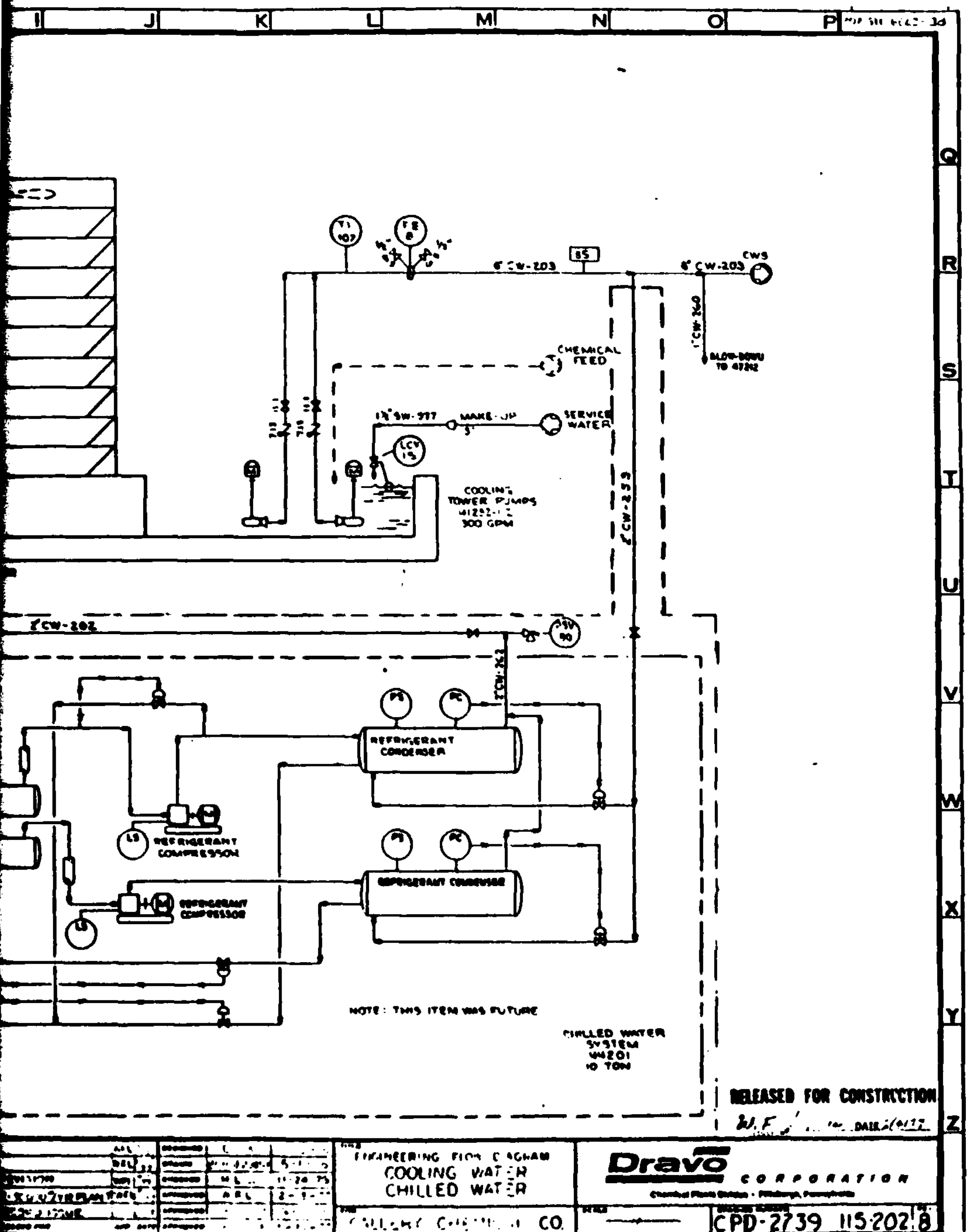
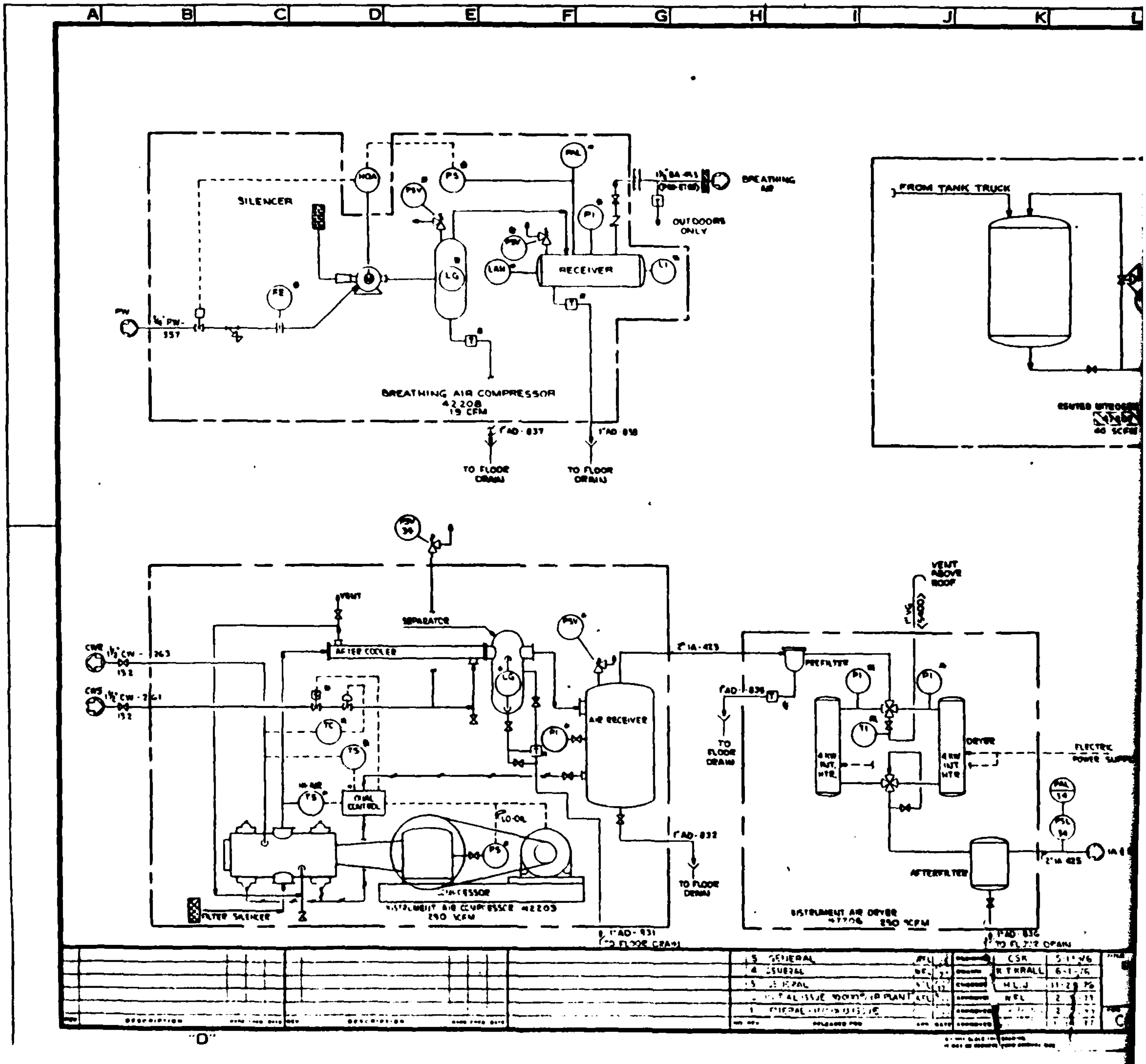
I
J
K
CWR
6" CW-258
FE 35
LCV 18
SERVICE WATER
WATER BREAK TANK
35231
500 GAL
PW
1" PW-355
PROCESS WATER PUMP
41233
20 GPM
TI 109
TI 107
95
COOLING TOWER
44203
300GPM
2"CW-282
PCV 96
AT END OF LOOP
2" CCW
CCWR
3"CCW-275
(P 50)
CCWS
3"CCW-272
(P 45)
49
45
48
TS
PS
CHILLED WATER COOLER
TC
ELECTRICAL TRACED SECTION OF PIPE FOR ANTI-FREEZE PROTECTION DURING SHUT DOWN
POWER TRACING CONTROLLER BY ELECT.
REFRIGERANT COMPRESSOR
PROCESS WATER
1" PW-822
3" CCW-275
CHILLED WATER PUMP
60 GPM
GENERAL
GENERAL REVISION
"D"

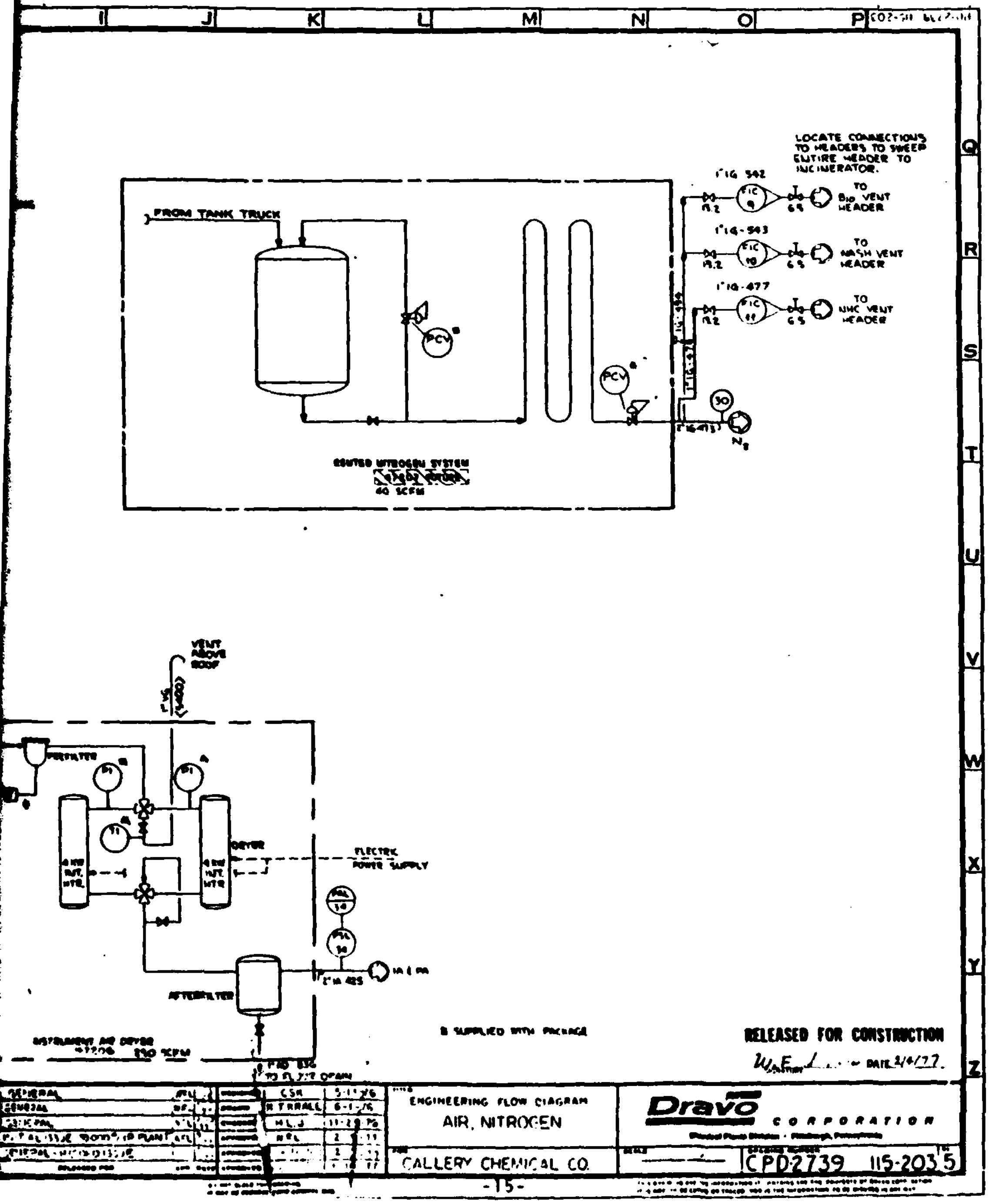


TI 107
FE 8
6" CW-203
6" CW-203
CWS
1" CW-260
BLOW-DOWN TO 41202
CHEMICAL FEED
1½" SW-277
MAKE-UP
SERVICE WATER
LCV 15
COOLING TOWER PUMPS
300 GPM
2" CW-202
REFRIGERANT CONDENSER
REFRIGERANT COMPRESSOR
REFRIGERANT CONDENSER
REFRIGERANT COMPRESSOR
NOTE: THIS ITEM WAS FUTURE
CHILLED WATER SYSTEM
W4201
10 TON
RELEASED FOR CONSTRUCTION
ENGINEERING FLOW DIAGRAM
COOLING WATER
CHILLED WATER
CO.
Dravo
CORPORATION
CPD-2739 115-202 8

2

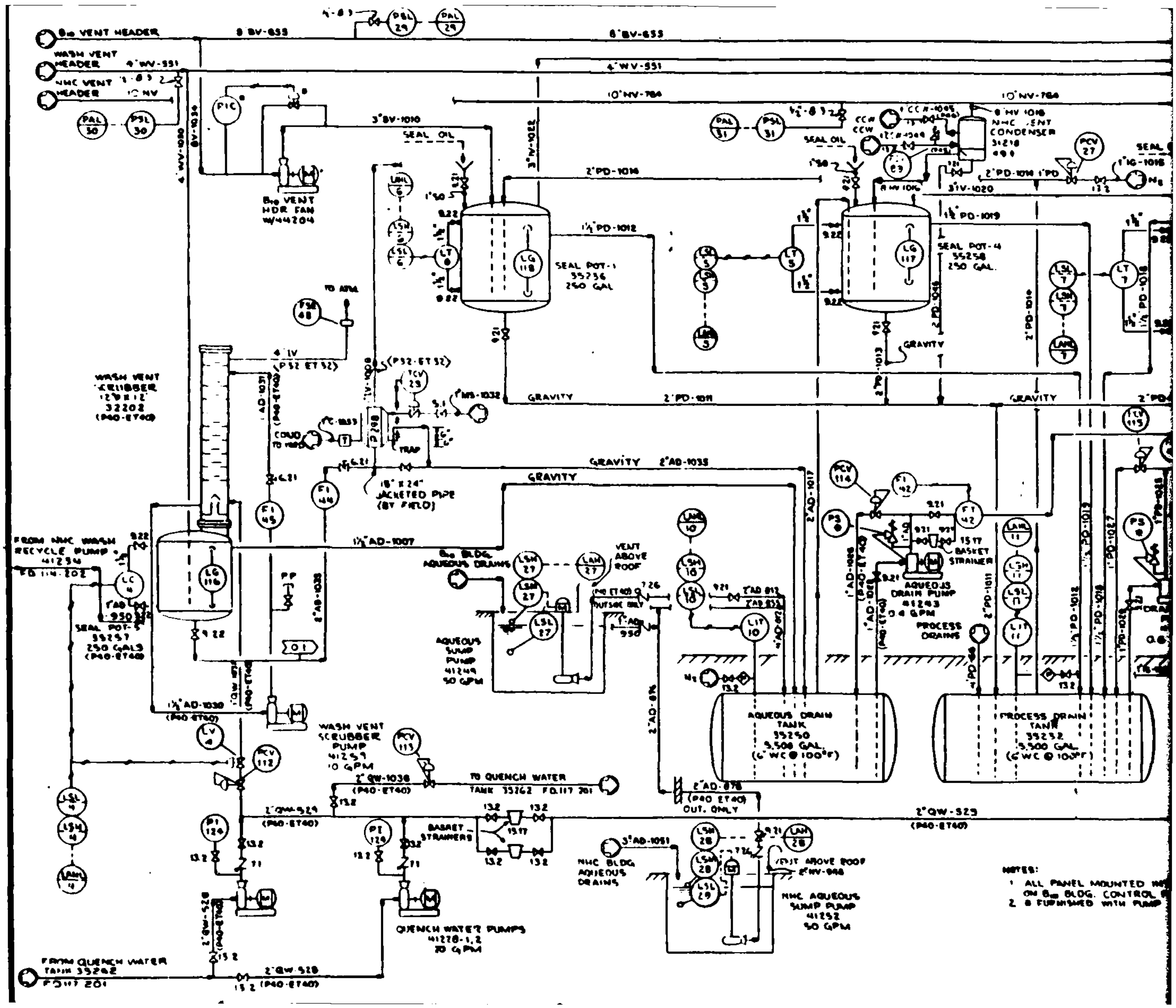


SILENCER
BREATHING AIR
OUTDOORS ONLY
RECEIVER
BREATHING AIR COMPRESSOR
42208
19 CFM
TO FLOOR DRAIN
TO FLOOR DRAIN
FROM TANK TRUCK
VENT
SEPARATOR
AFTER COOLER
AIR RECEIVER
VENT ABOVE ROOF
PREFILTER
DRYER
ELECTRIC POWER SUPPLY
AFTERFILTER
DUAL CONTROL
LO-OIL
FILTER SILENCER
INSTRUMENT AIR COMPRESSOR 42203
290 SCFM
INSTRUMENT AIR DRYER
290 SCFM
TO FLOOR DRAIN
GENERAL
DESCRIPTION
RELEASED FOR
"D"

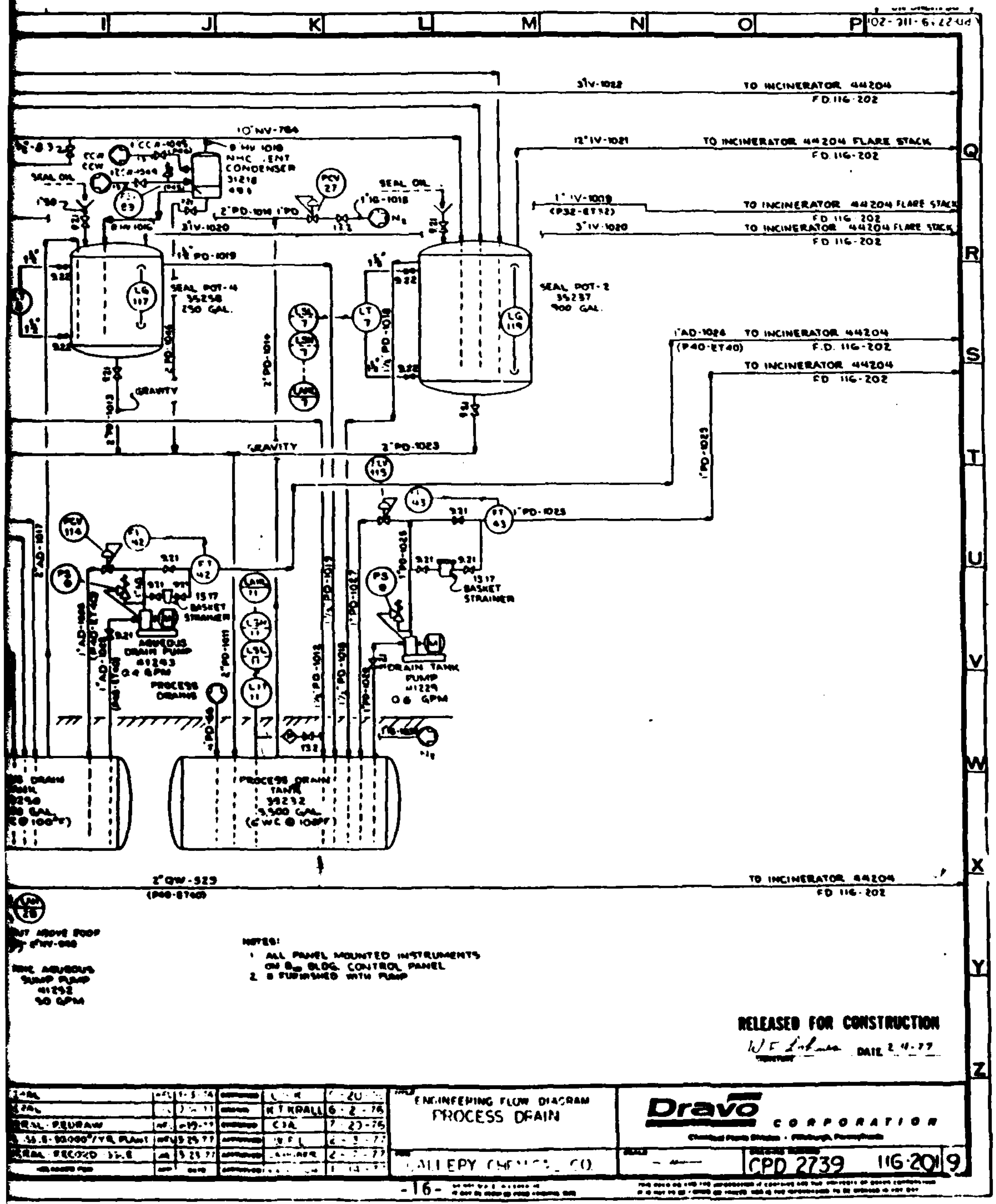

LOCATE CONNECTIONS TO HEADERS TO SWEEP ENTIRE HEADER TO INCINERATOR.
FROM TANK TRUCK
TO B_{10} VENT HEADER
TO WASH VENT HEADER
TO UHC VENT HEADER
PCV
N_2
40 SCFM
VENT ABOVE ROOF
PREFILTER
DRYER
ELECTRIC POWER SUPPLY
AFTERFILTER
INSTRUMENT AIR DRYER
B SUPPLIED WITH PACKAGE
RELEASED FOR CONSTRUCTION
ENGINEERING FLOW DIAGRAM
AIR, NITROGEN
CALLERY CHEMICAL CO.
Dravo CORPORATION
CPD2739 115-203 5

2

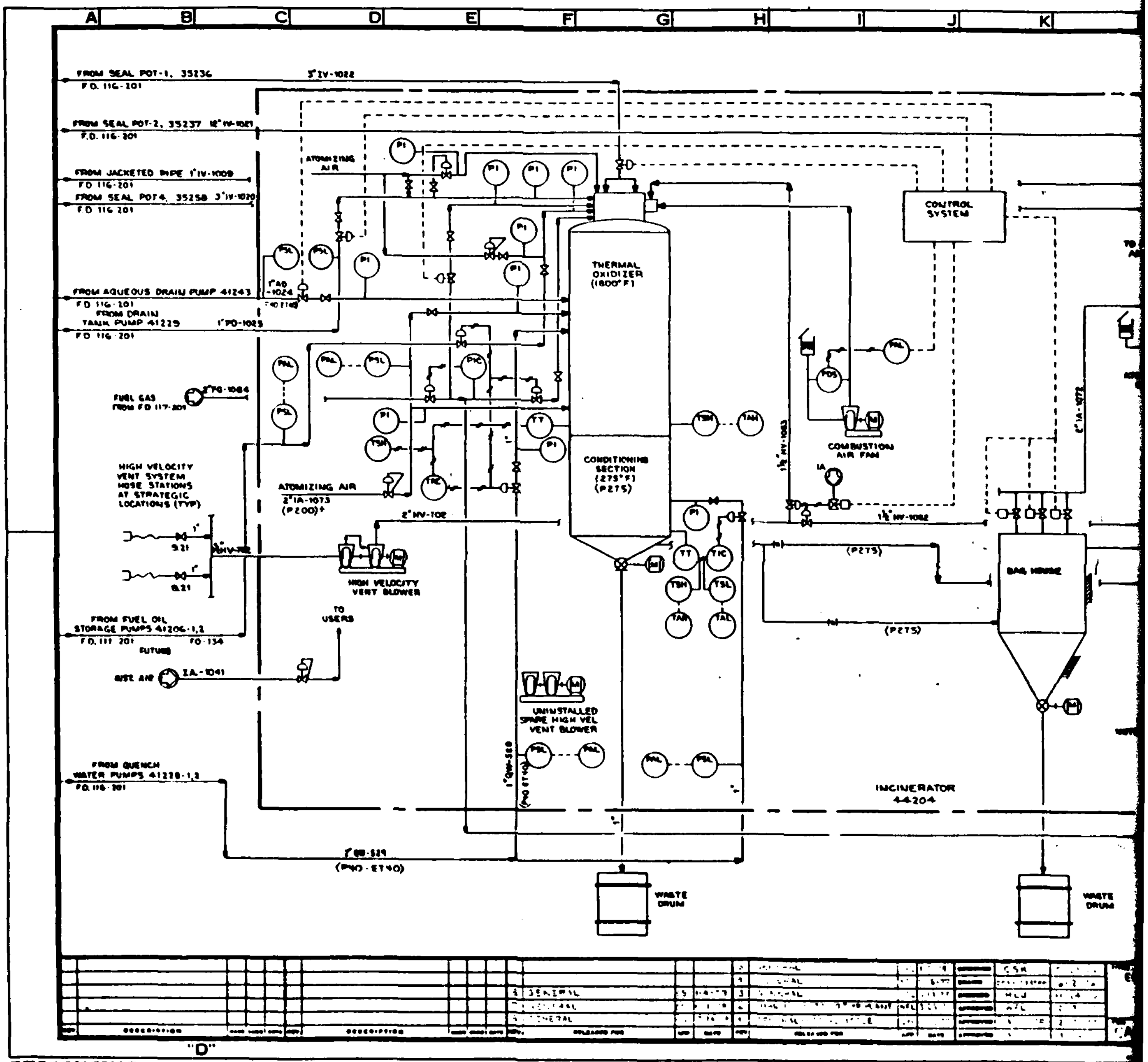
|



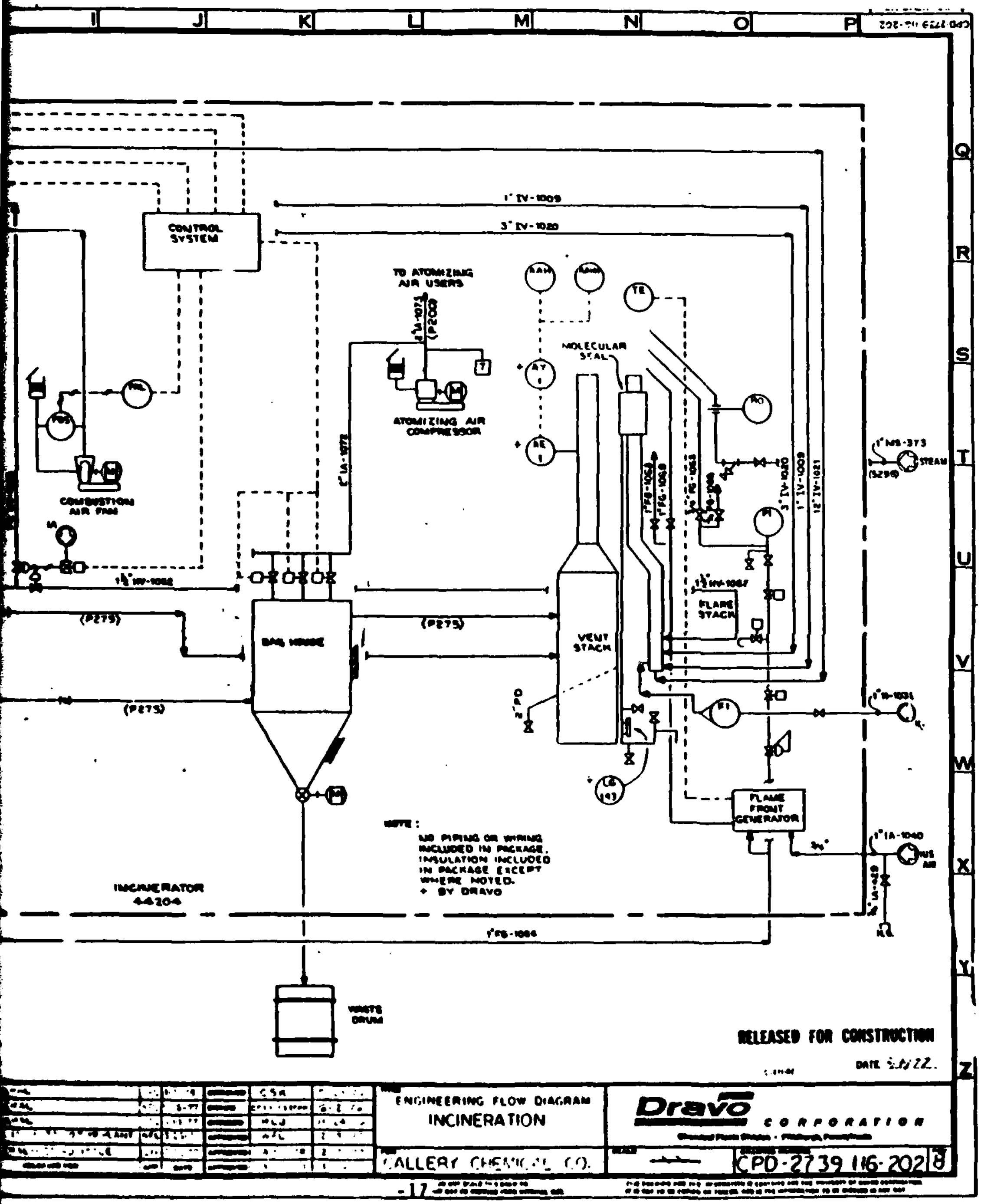
B10 VENT HEADER
8"BV-655
WASH VENT HEADER
4"WV-551
NHC VENT HEADER
10"NV-784
PAL 30
PSL 30
PSL 29
PAL 29
FIC
3"BV-1010
SEAL OIL
B10 VENT HDR FAN W/44204
2"PD-1014
1½"PD-1012
SEAL POT-1 35256 250 GAL
LG 118
LT 6
LSH 6
LSL 6
PAL 31
PSL 31
NHC VENT CONDENSER
SEAL POT-4 35258 250 GAL.
LG 117
LT 5
GRAVITY
2"PD-1011
WASH VENT SCRUBBER 12"Ø x 12' 32202 (P40-ET40)
FSH 48
TO ATM.
18" x 24" JACKETED PIPE (BY FIELD)
TRAP
GRAVITY 2"AD-1035
1½"AD-1007
FI 45
FI 44
LG 116
LC 4
SEAL POT-5 35257 250 GALS (P40-ET40)
FROM NHC WASH RECYCLE PUMP 41254
B10 BLDG. AQUEOUS DRAINS
VENT ABOVE ROOF
LSH 27
LAH 27
LSL 27
AQUEOUS SUMP PUMP 41249 50 GPM
LAH 10
LSH 10
LSL 10
LIT 10
PCV 114
FI 42
FT 42
BASKET STRAINER
AQUEOUS DRAIN PUMP 41243 0.4 GPM
PROCESS DRAINS
AQUEOUS DRAIN TANK 35250 5,500 GAL. (6"WC @ 100°F)
PROCESS DRAIN TANK 35252 5,500 GAL. (6"WC @ 100°F)
WASH VENT SCRUBBER PUMP 41253 10 GPM
PCV 113
TO QUENCH WATER TANK 35262 F.D.117 201
2"QW-1036 (P40-ET40)
2"QW-525 (P40-ET40)
LV 4
PCV 112
LSL 4
LSH 4
PI 124
PI 125
BASKET STRAINERS
2"AD-878 (P40 ET40) OUT. ONLY
3"AD-1051
NHC BLDG AQUEOUS DRAINS
LSH 28
LAH 28
VENT ABOVE ROOF 2"NV-946
NHC AQUEOUS SUMP PUMP 41252 50 GPM
QUENCH WATER PUMPS 41278-1,2 20 GPM
FROM QUENCH WATER TANK 35262 F.D.117 201
2"QW-528 (P40-ET40)
NOTES:
1 ALL PANEL MOUNTED IN
ON B10 BLDG. CONTROL
2. FURNISHED WITH PUMP


TO INCINERATOR 44204
FD 116-202
TO INCINERATOR 44204 FLARE STACK
NHC VENT CONDENSER
SEAL OIL
SEAL POT-4
35258
250 GAL.
SEAL POT-2
35257
900 GAL.
GRAVITY
BASKET STRAINER
AQUEOUS DRAIN PUMP
41243
0.6 GPM
PROCESS DRAINS
DRAIN TANK PUMP
41229
0.6 GPM
PROCESS DRAIN TANK
35232
9,500 GAL.
NOTES:
1. ALL PANEL MOUNTED INSTRUMENTS ON B BLDG. CONTROL PANEL
2. FURNISHED WITH PUMP
RELEASED FOR CONSTRUCTION
ENGINEERING FLOW DIAGRAM
PROCESS DRAIN
Dravo
CORPORATION
CPD 2739
116-201
9

2



A
B
C
D
E
F
G
H
I
J
K
FROM SEAL POT-1, 35236
3" IV-1022
F.D. 116-201
FROM SEAL POT-2, 35237
F.D. 116-201
FROM JACKETED PIPE 1" IV-1009
F.D 116-201
FROM SEAL POT4, 35258 3" IV-1020
F.D 116 201
ATOMIZING AIR
CONTROL SYSTEM
THERMAL OXIDIZER (1800°F)
FROM AQUEOUS DRAIN PUMP 41243
F.D 116-201
FROM DRAIN TANK PUMP 41229
1" PD-1025
F.D 116-201
FUEL GAS FROM F.D 117-201
COMBUSTION AIR FAN
CONDITIONING SECTION (275°F) (P275)
HIGH VELOCITY VENT SYSTEM HOSE STATIONS AT STRATEGIC LOCATIONS (TYP)
ATOMIZING AIR
2" IA-1073
(P200)
2" HV-102
HIGH VELOCITY VENT BLOWER
(P275)
BAG HOUSE
FROM FUEL OIL STORAGE PUMPS 41206-1,2
F.D. 111 201
TO USERS
FUTURE
INST AIR
IA-1041
UNINSTALLED SPARE HIGH VEL VENT BLOWER
FROM QUENCH WATER PUMPS 41228-1,2
F.D. 116-201
INCINERATOR 44204
(P40-ET40)
WASTE DRUM
WASTE DRUM
GENERAL
"D"



I
J
K
L
M
N
O
P
Q
R
S
T
U
V
W
X
Y
Z
CONTROL SYSTEM
1" IV-1009
3" IV-1020
TO ATOMIZING AIR USERS
ATOMIZING AIR COMPRESSOR
MOLECULAR SEAL
COMBUSTION AIR FAN
1" IA-1072
1½" HV-1082
(P275)
BAG HOUSE
(P275)
VENT STACK
1½" HV-1087
FLAME STACK
3" IV-1020
1" IV-1009
12" IV-1021
1" MS-373
(S290)
STEAM
1" N-1031
FLAME FRONT GENERATOR
1" IA-1040
NOTE:
NO PIPING OR WIRING INCLUDED IN PACKAGE. INSULATION INCLUDED IN PACKAGE EXCEPT WHERE NOTED.
+ BY DRAVO
INCINERATOR 44204
1" FG-1084
WASTE DRUM
RELEASED FOR CONSTRUCTION
ENGINEERING FLOW DIAGRAM
INCINERATION
CALLERY CHEMICAL CO.
Dravo
CORPORATION
CPD-2739 116-202
-17

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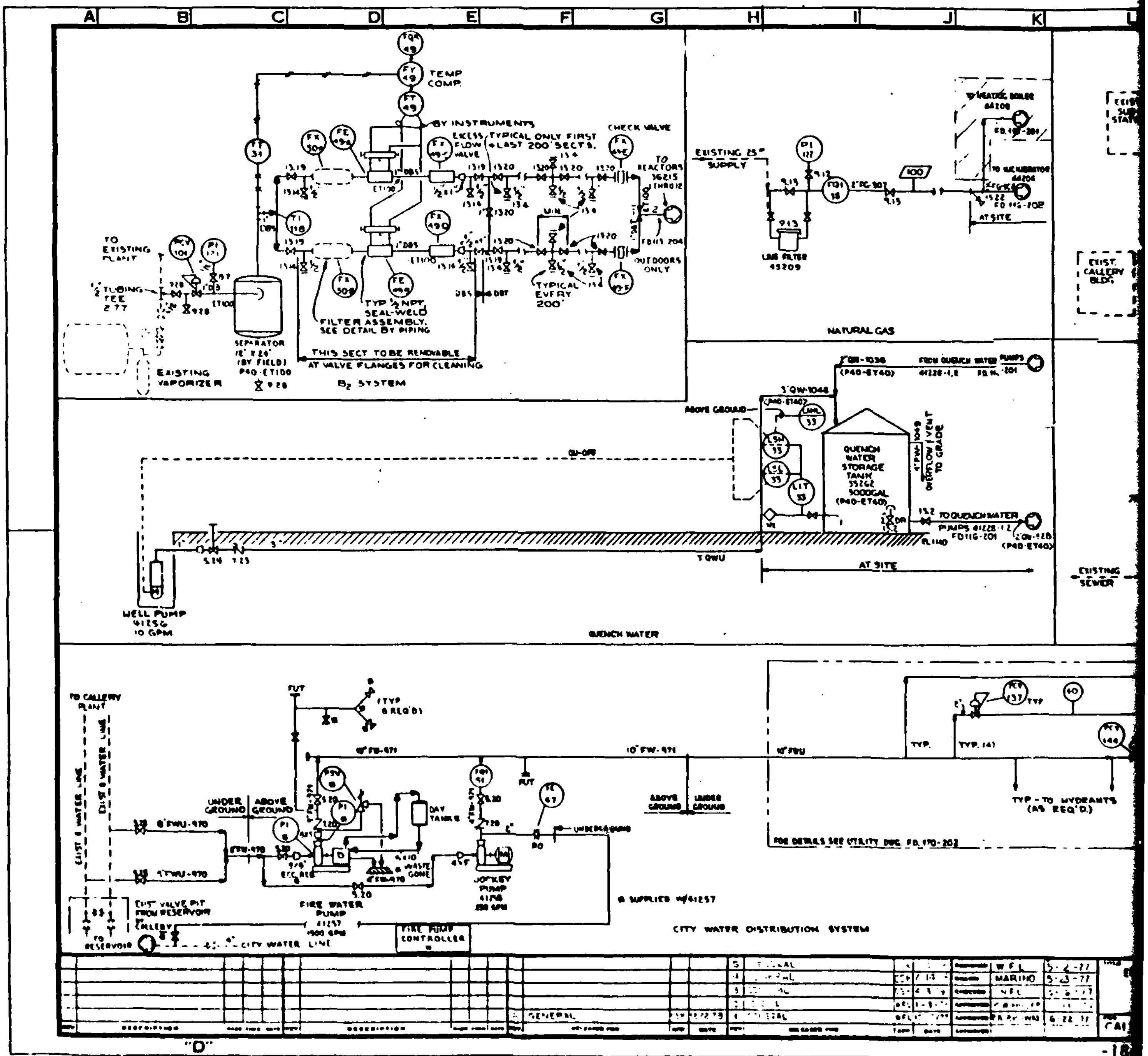
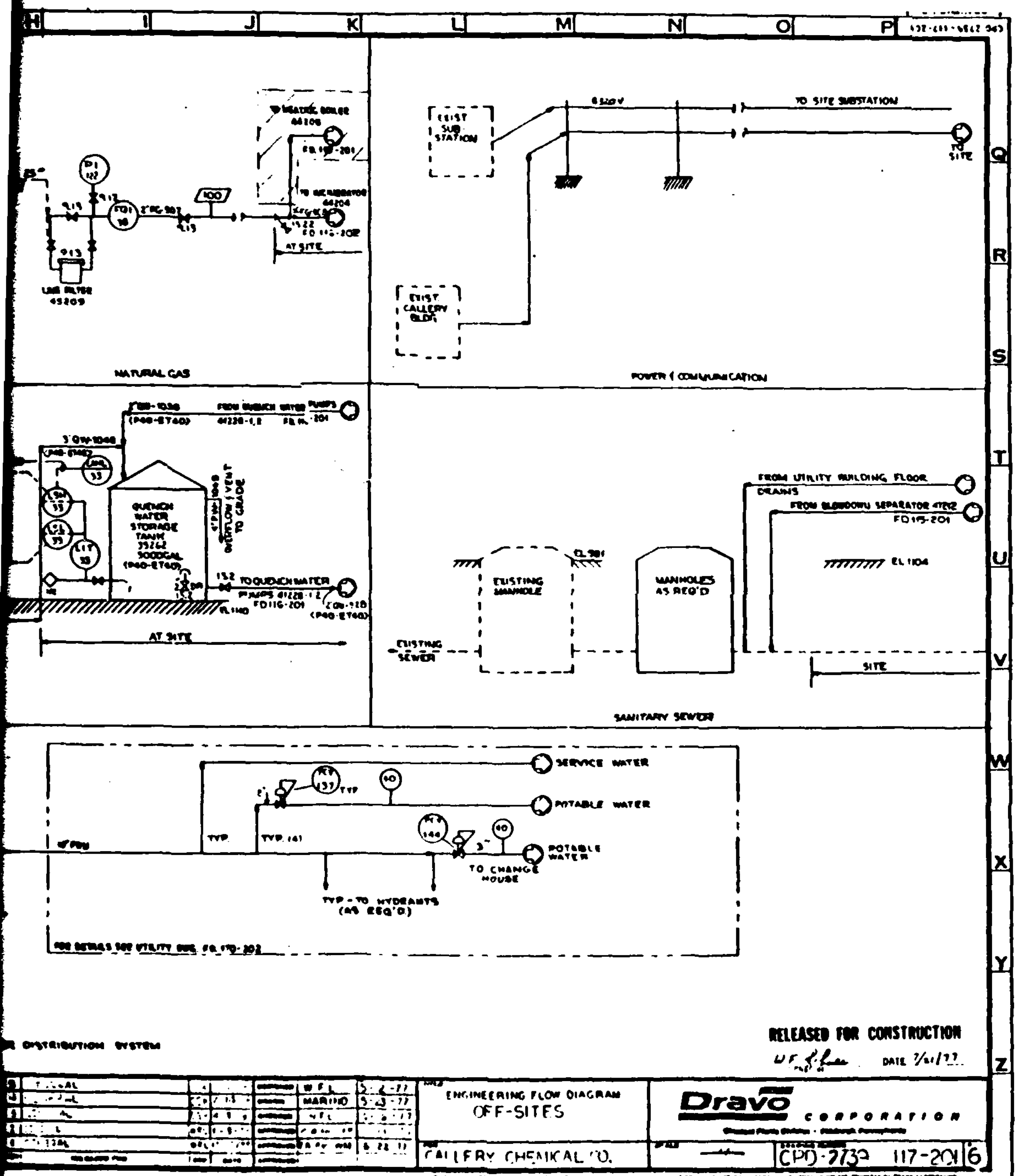


TEMP COMP.
BY INSTRUMENTS
EXCESS FLOW VALVE
TYPICAL ONLY FIRST & LAST 200 SECT'S.
CHECK VALVE
TO REACTORS
TO EXISTING PLANT
TUBING TEE
EXISTING VAPORIZER
SEPARATOR
TYPICAL EVERY 200'
OUTDOORS ONLY
TYP 1/2 NPT SEAL-WELD
FILTER ASSEMBLY. SEE DETAIL BY PIPING
THIS SECT TO BE REMOVABLE AT VALVE FLANGES FOR CLEANING
B_2 SYSTEM
EXISTING 25# SUPPLY
NATURAL GAS
AT SITE
ABOVE GROUND
QUENCH WATER STORAGE TANK
OVERFLOW / VENT TO GRADE
TO QUENCH WATER
WELL PUMP
10 GPM
QUENCH WATER
EXISTING SEWER
TO CALLERY PLANT
UNDER GROUND
ABOVE GROUND
DAY TANKS
FIRE WATER PUMP
JOCKEY PUMP
FIRE PUMP CONTROLLER
CITY WATER LINE
TO RESERVOIR
TYP - TO HYDRANTS (AS REQ'D.)
CITY WATER DISTRIBUTION SYSTEM
GENERAL
"D"


NATURAL GAS
POWER & COMMUNICATION
EXIST SUB STATION
EXIST CALLERY BLDG
TO SITE SUBSTATION
TO SITE
QUENCH WATER STORAGE TANK
AT SITE
EXISTING MANHOLE
MANHOLES AS REQ'D
EXISTING SEWER
FROM UTILITY BUILDING FLOOR DRAINS
SITE
SANITARY SEWER
SERVICE WATER
POTABLE WATER
TO CHANGE HOUSE
TYP - TO HYDRANTS (AS REQ'D)
DISTRIBUTION SYSTEM
RELEASED FOR CONSTRUCTION
ENGINEERING FLOW DIAGRAM
OFF-SITES
CALLERY CHEMICAL CO.
Dravo CORPORATION
CPD-2739 117-201 6

2

APPENDIX C

RELIABILITY, AVAILABILITY, MAINTAINABILITY ANALYSIS REPORT

RELIABILITY, AVAILABILITY, MAINTAINABILITY ANALYSIS REPORT

Abstract

The reliability, availability and maintainability of the processes and equipment being designed for the production of n-Hexyl Carborane at the Callery Chemical Company facility have been examined. The critical components of the system have been reviewed for operating conditions, materials of construction and criticality of function and the potential modes of failure have been described. A reliability factor has been applied for each potential mode of failure. A maintainability factor of repair time has been estimated for the various failure modes and the estimated availability of each critical subsystem has been calculated. The overall plant availability has been estimated using the individual subsystem availabilities and a facility block diagram. Reliability factors relating to long term plant layaway are discussed and layaway and reactivation procedures are discussed in general. The overall facility availability has been estimated to be .883, requiring 340 days per yr. to have available 300 stream days, versus a contract requirement availability of .822, requiring 365 days per yr. to have available 300 stream days.

RELIABILITY, AVAILABILITY, MAINTAINABILITY ANALYSIS

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APPENDICES

I. Purpose

Callery Chemical Company has been directed by technical requirement #6116 of Contract No. DAAK40-76-C-1256 to design the low cost NHC facility with reliability, availability and maintainability as major considerations. The TR specifies that:

> "The contractor shall include reliability, availability, and maintainability as design parameters of equal importance with other technical and functional parameters. This will include the establishment of reliability/availability, maintainability goals and requirements.
>
> The facility design shall include standardization, corrosion and deterioration prevention and human engineering factors.
>
> The contractor shall establish a quantitative system availability, utilizing a block diagram of the system; this availability will be apportioned among the critical major subsystems.
>
> The contractor shall perform an availability prediction entailing a prediction of each critical major subsystem availability based on the knowledge of the parts, functions, operating environments, and their interrelationships. These predicted values will be compared to the apportioned values and if required, appropriate changes in the design will be accomplished based on this analysis. A report per DI-R-3535/R-103-2MOD as amended, shall be furnished the Government as part of the final report."

This study has been completed primarily to determine:

1. The operability and maintenance problems to be expected in the new facility or
2. Those areas requiring additional design effort.

Secondarily, this report is furnished to fulfill contract requirements.

II. Summary

A. Requirements and Results

This report outlines the reliability, availability

and maintainability parameters incorporated into the design of the NHC facility to be constructed at Callery Chemical Company. These parameters were considered to be equally important with other functional parameters. Availability goals were established utilizing a block diagram of the NHC process and the availability goal was apportioned to the critical systems; B10, NHC, Waste Disposal and Utilities. Based on the knowledge of operating conditions, equipment function and construction materials, each critical major subsystem has been examined and assigned a predicted availability. At a design basis of 30,000 lb. NHC per 300 stream day yr. an overall system availability of .822 is required to meet production goals. The predicted overall system availability of .883 requires 340 days per yr. to meet production demands. This will allow for operability items which take longer to repair than predicted or which fail at a higher rate than expected.

B. Definitions and Assumptions

The reliability, availability and maintainability analyses which have been performed have been based on several definitions. They include the following:

Reliability - How frequently a subsystem will fail, or MTBF, mean time between failures.

Maintainability - How long will the system be shut down after a failure, or MTTR, mean time to repair.

Availability - The fraction of time the system is expected to be operating or MTBF/(MTBF + MTTR)

Criticality - The assessment of the extent of system shutdown for short and long-term failure.

Critical Systems - Those systems which, if failed, would stop production until the system is repaired and their function cannot be taken over by other equipment. Eg.: NHC Reactor

Subcritical Systems - Those systems which if failed, would reduce production but can be bypassed to alternate equipment at reduced capacity. Eg.: The R-3 Reactor.

Potential Mode of Failure - Any occurrence of random frequency which will cause an immediate subsystem shutdown or which repair time exceeds the turnaround time and causes delays in processing.

Equivalent Downtime - The measure of productivity lost after the failure of a subcritical system whose function is taken over by another critical system causing reduced capacity.

There have been assumptions made which affect the availability analysis which has been performed. It has been assumed that all material not meeting specification can be reprocessed with some equivalent downtime but no loss of the full production batch. It has also been assumed that there will be no disaster situations (major fire, explosion or natural disaster) which will cause the destruction of long delivery time, equipment and equivalent rebuilding time at this facility or critical supplier facility. There is no allocation for labor relations problems which might force temporary plant closing or long-term reduced operation. Consideration has been given to the operating conditions which equipment will encounter. High temperature, high viscosities, corrosive materials and foam prone materials in subsystems increase the probability of failure and lower reliabilities have been assumed in these cases.

C. Conclusions and Recommendations

Many of the design considerations for the proposed NHC Plant have been based on the extensive operating experience of Callery Chemical Company personnel and the design experience of Dravo Corporation, the design subcontractor. Callery has been developing and manufacturing boron hydride chemicals and engineering process systems to handle these toxic, flammable and often pyrophoric chemicals for many years. Repairing equipment containing these chemicals is hazardous and safety has been a major consideration of Callery for the existing plant and for the new NHC facility. Quite often the reliability of a piece of equipment has a large bearing on the safety of the process so that those aspects have been studied in the design effort.

The process fluids being handled are generally flammable, toxic or reactive so that the system has been designed to minimize leaks and spills and vapor loss to the process buildings. All equipment in contact with boron containing fluids is to be stainless steel to avoid product contamination. The more durable, corrosion resistant stainless steel will improve the

reliability significantly over carbon steel equipment. All pumps and agitators in contact with boron containing fluids will have high reliability mechanical seals to prevent significant leakage. Most of the gasketing materials will be teflon or equivalent, carbon or carbon filled teflon for long life. Most other materials will swell, crack, or otherwise deteriorate. For the process hardware most piping is welded or is fitted with high pressure flanges and valves will have high resistance teflon seats. Although these design items add to the cost, the reliability and safety improvements warrant the added cost.

All of the process systems operate under slightly positive pressure (less than 5 psig) or under high-vacuum. The low positive pressure operations reduce the mechanical stresses found in alternate moderate or high pressure synthesis routes. The low pressure also limits the severity of process fluid leaks. The vacuum pumps in the high vacuum systems are protected by methanol-dry ice cold traps (-108°F) to prevent corrosive attack and solids deposition by volatile borane chemicals and reduce mechanical stress by limiting vapor flow to the pumps.

Actual tests of incineration of simulated process liquid wastes have been performed and successful collection of the innocuous solid wastes has been demonstrated. The operation of this critical system will protect the environment and reduce operator hazard. The vendor design of this complex system is now based on actual testing rather than less reliabile speculative operating conditions. The original design as conceptualized proved to be faulty but the modifications incorporated after testing will improve the long term performance of the unit.

Maintainability of the process equipment has been enhanced by the Dravo construction of fully piped processed models. Maintenance can be performed without the interference from other equipment and piping that is often found in layouts from the drawing board. Easy access to critical components of systems has been established by the modeling.

Preventive maintenance programs for the facility equipment will be thorough and based on the recommendations of the vendor equipment manuals and the experience of Callery operating personnel. Since these manuals are not yet available specific maintenance pro-

cedures cannot be outlined.

To facilitate maintenance some of the pumps specified (in line pumps) are of a design which do not require the disassembly of the motor or the process piping to replace the pump internals. Mechanical seals and other rotating parts are easily accesstble.

In order to insure proper equipment selection for reliable performance, a procedure was undertaken involving Callery and Dravo personnel. After input by Callery concerning operating conditions for a group of equipment, a general specification (eg. Heat Exchangers) was written by the appropriate Dravo group. Vendor equipment performance guarantees were written into the spec as well as the necessary materials of construction and corrosion protection instructions. Following Dravo Management review and approval, the general Spec was reviewed and amended or accepted by the appropriate member of the Callery project group. The specific item spec (eg. Pentane Condenser) was then written, followed the approval pattern. The equipment specs were sent to several vendors for quotations and a quotation analysis was performed after the quotes were received. These Dravo quotations analyses were reviewed by Callery and the specified vendor was approved or changed after review of the quotes. In all of the reviews by Callery and Dravo, reliability, function, safety and cost were major considerations. The Government Project Management has also had specification approval during the design reviews.

Equipment maintenance records will be kept to detect equipment that has an abnormally high failure record. This will aid in the selection of new equipment if some pieces need to be replaced. It will also point out where improved preventive maintenance procedures are required. These records will aid in the availability analysis which is to be performed for Contract No. DAAK-40-76-C-1256, TR #6116, Report BOOC, 19 months after the exercise of Option II and 15 months after the exercise of Option IV.

The RAM analysis shows that the facility systems will be available for a sufficient period to allow Callery Chemical Company to meet production requirements for NHC. There should be available time to be able to close the plant for a scheduled two week summer maintenance program. This may, in fact, be required if the existing Callery facility continues its summer shutdown

program and diborane becomes unavailable.

D. Long Term Storage Effects

1. Summary

Long term storage will have no significant effect on the reliability of the NHC production facility. Some items would be partially dismantled for storage but the majority of equipment would be thoroughly cleaned, inerted and sealed. Reactivation would require the probable replacement of seals and gaskets and thorough leak testing of the entire system.

2. Discussion

a. Deactivation

In the event of deactivation and long term storage of the NHC production facility, Callery Chemical Company would be required to follow a thorough and orderly shutdown procedure to minimize deterioration in the laid-away plant. This procedure must also allow for the removal of reactive chemical residue in equipment.

The in-service diborane pipe line would be inerted, cleaned and sealed by our standard procedure. Consideration would be given to removing the pipe sections crossing route 855. Pipe deterioration would be no greater than normal. In the B10 area, the reactors would be thoroughly cleaned with solvents, purged with nitrogen and sealed. The heating mantles would be removed and stored to prevent moisture attack. The auxiliary systems, hexane recovery and dissolver-filter would be washed out and inerted. The majority of the building piping is stainless steel and should suffer no damage. Carbon steel systems are protected from the environment.

In the NHC area, all equipment will be washed free of all residue, nitrogen dried and sealed. Fresh lubricating oil would be added to vacuum pumps and other oil systems. All equipment inside the NHC building could remain in place without concern regarding reliaoility after layaway.

All supporting systems could be shutdown, the cooling tower flushed and drained, the

boiler purged, air compressors turned off. Any cooling needed could be provided with plant water. Outside pumps could be protected against the weather but it should not be necessary to dismantle and store pumps.

The incinerator system should be one of the last systems to go into layaway so that all waste solvents from cleaning and aqueous wastes from washdowns could be consumed. The filter bags should be removed from the baghouse and cleaned. All moisture-absorbing solids, such as the sodium borate or boric acid should be removed first as dry powder and then water washed to the MSA/Callery effluent system. Burner nozzles would be removed and the incinerator furnace sealed. The baghouse shell, which depends partially on its temperature against corrosive moisture attack, may suffer some deterioration due to weathering. The cleaning of soluble, corrosive salts will significantly slow attack on the baghouse shell.

b. <u>Layaway</u>

During layaway a program of occasional corrosion inhibiting painting would need to be instituted. Equipment would be physically safeguarded only by the fence; however, this should be sufficient.

c. <u>Reactivation</u>

There will be reliability problems during startup after a long-term shutdown. Most of the problems will be minor in nature and probably only last through the startup period. Many seals will fail due to normal compression set of elastomeric materials. Pumps and other rotating equipment will need to be thoroughly tested before reactivation. Regular gasketing materials should not deteriorate to failure, but piping systems will need to be pressure leak tested. Process vessels will require the same inspections.

Electrical contacts often have the tendency to form oxide coatings during long periods of non-use, and this will also cause post layaway startup problems. Failure of control systems may be a hazard during reactivation, but these problems should be noted only during startup.

After the reactivation startup with the above problems, the facility should return to the mode of random failure until the plant nears the end of its economic life.

III. System Description

A. Narrative Description

NHC is produced in a two phase operation, the continuous pyrolysis of decaborane B10 from diborane B2 in the B10 Building and the batchwise solution synthesis of NHC from B10 in the NHC Building, following the flow of the system block diagram (Figure #1).

Diborane is piped from the Callery production facility into the B2 distribution system of the B10 Building. Metered amounts of B2 are fed into the first stage of the convective circulation pyrolysis reactor. Decaborane and boron hydride intermediates and polymer are formed in the heated leg of each stage. The B10 is condensed in the chilled water cooled leg of the reactor and removed by a mechanical scraper. After several recirculative passes, the product gases containing B2 are bled into the second stage of the three stage reactor. The same heated/cooled configuration applies in the second and third stages. After the third stage reaction recirculation, the high hydrogen, low B2 off gases are vented to waste disposal. At the completion of a 15 shift operation, the reactor is purged with nitrogen and the collected product hoppers are disconnected and dumped into the dissolver. The B10 remaining in the reactor loops is washed out with solvent hexane which is evaporated to yield crystalline B10 when the hexane reaches saturation. The reactor is then washed with methanol-acetone which will digest any remaining BH Polymer. This waste solvent is drained to the process drain tank for incineration. The B10 dissolved in reaction solvents R1 and R2 is filtered and transferred to the NHC Building.

In the NHC Building, the dissolved B10 is processed batchwise through several operations to yield crude NHC. This crude NHC is purified by solvent extraction, washing and distillation to yield a high purity product which is drummed off for shipment.

In the R3 Reactor, the dissolved B10 is mixed with R3 to form a B10 sulfide liquid. This exothermic reaction continues over a 24-hr. period. This reaction product is then transferred to the NHC Reactor feed pot which adds the sulfide product into refluxing R1 and 1-octyne. After the NHC reaction is completed

in two hours, total reflux is continued for an hour and then the excess reaction solvents are stripped under vacuum. The NHC containing reactor residue is pressure transferred to the planetary mixer where R4 is added to digest non-NHC decaborane species. This viscous solution is then extracted with four pentane additions. The NHC is dissolved in the pentane and a tarry residue remains in the planetary mixer. This residue is thinned with toluene and is transferred to the process drain tank.

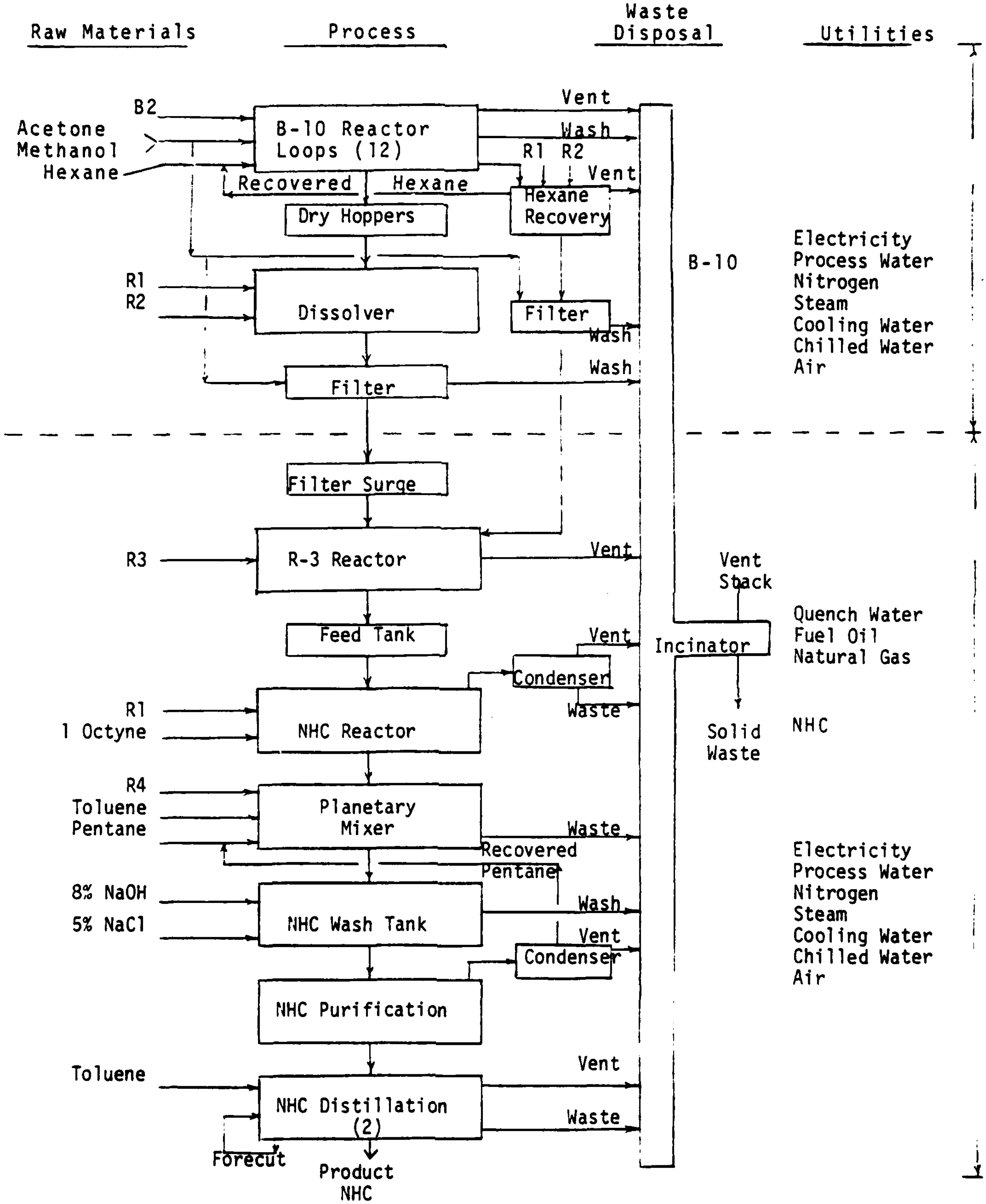
The pentane-NHC solution is washed with caustic and salt water washes in the NHC wash tank. The washed Pentane-NHC extract is pumped to the NHC purification kettle. In this kettle the majority of the pentane is stripped from the solution using low pressure steam in the kettle jacket. The recovered pentane is then pumped back to storage. The NHC containing residual is pumped to the vacuum distillation unit where the forecut from the previous batch is recycled. Three overhead cuts are taken in this high vacuum unit. The first waste cut contains mostly pentane and other volatile organics and organoboranes remaining after the NHC purification atmospheric distillation. The second cut, the forecut, is high in NHC but contains too many volatiles and is held for recycle. The final overhead cut is the product which is pumped to drums, analyzed, weighed and prepared for shipment. The residue remaining in the pot after the temperature reaches 392^{o}F. and the pressure reduced to .5 mmHg absolute is cooled and thinned with toluene and pumped to the process drain tank.

All of the waste from the facility with the exception of the sanitary sewage is disposed of in the waste disposal unit. The boron containing organic liquids all drain to the process drain tank. The plant aqueous wastes, the caustic/salt washes, floor washings and boiler water conditioner regenerative waste all drain to the aqueous drain tank. Both of these drain tanks feed into the incinerator. The four vent headers from the two process buildings also feed into incinerator. The B10 vent header containing B2, hydrogen and nitrogen, the wash vent containing volatile organics from the B10 Building and the NHC vent header containing volatile organics from the NHC Building vent to the incinerator after discharging through seal pots. The high velocity header, primary for dust and toxic vapor collection discharges directly to the incinerator and is used as combustion air. The incinerator gasses are quenched to 400^{o}F. The particulates, mostly sodium carbonate,

sodium chloride and sodium borate salts, are collected in a baghouse and drummed off for contract landfill. A fourth seal pot is provided as overload protection for the 3 vapor stream seal pots in an upset condition. At high vapor flow rates the 6" water pressure is overcome and the excess gases vent ot the emergency flare for safe combustion.

Electricity, natural gas, process water and liquid nitrogen are supplied by outside utility companies. Steam, gaseous nitrogen, cooling water and compressed instrument air are utilities which are produced on site. All of the utilities have excellent availability.

B. NHC FACILITY BLOCK DIAGRAM



C. NHC FACILITY PREDICTED SYSTEMS AVAILABILITY SUMMARY

B-10 Area

.995	B-10 Reactor Loops *	.90
	Dissolver-Filter	.995
	Hexane Recovery	1.00

NHC Area

.9243	R-3 Reactor	.995
	NHC Reactor	.98
	Planetary Mixer	.975
	NHC Wash Tank	.997
	NHC Purification	.985
	NHC Distillation	.99

Waste Disposal

.970	Incinerator	.975
	Tanks and Pumps	.995

Utilities

.990	Steam, N2, Water, Gas	1.00
	Cooling Water, Air, Power	.99

AI = A B-10 X A NHC X A WD X A UT

AI = .995 X .9243 X .97 X .99

AI = .883

Design Basis: 30,000 lb./300 Stream Day Yr.

A I.D. = 300/365 = .822

Predicted System Availability, .883 Requires 300/.883 or 340 days per yr. scheduled operation. This would permit two week annual maintenance shutdown.

*B-10 Reactor Loops not critical if availability is not less than overall system.

APPENDICES

I. Subsystem Summary

A. B-10 Reactor Loops Subsystem

1. Equipment and Function

The B10 Reactor Loops pyrolize the raw material diborane into the intermediate product decaborane.

One reactor (36215-17) consists of three convective circulation loops, each with an electrically heated vertical leg for pyrolizing the diborane feed to decaborane, a vertical chilled water jacketed leg for condensing the decaborane and two horizontal crossover legs. The byproduct hydrogen, intermediate boron hydrides and diborane are recirculated through each loop and bled into the successive loop. The primarily hydrogen off gas from the third loop is filtered (45206) and vented to a vent header. The product decaborane is mechanically scraped from the condensing walls into the product hoppers (35252) and some BH Polymer is entrained. After the reaction period the reactor is purged with nitrogen, the product hoppers sealed and removed and the loops flooded with hexane to dissolve any B10 in the reactor then flushed with a methanol-acetone mixture pumped (41213) from a head tank (36201) to dissolve any BH Polymer. BH Polymer entrained in the hexane wash is filtered (45201) and this filter is backflushed with methanol-acetone. The waste solvent is pumped to the process drain tank.

2. Criticality

The large number of reactors (12) running in parallel will yield a steady flow of decaborane. The overall availability of the twelve reactors must equal the overall availability (.822) of the entire plant in order to meet production demand. These conceptually new and complex reactors may have operational problems with flow restriction and plugging but the ongoing work on the pilot plant reactor design is yielding constant improvement in operability. Present expected availability is approximately 90% with additional washout but the continuing reactor design effort should result in an improvement. The methanol-acetone washout is a mechanically simple system with boron polymer dissolution rapid and complete. Potential modes of failure are quickly and easily corrected allowing a high availability in the washout system.

3. Potential Modes of Failure - Cause & Effect Probability

Reactor Pluggage - Solids buildup in crossovers will shutdown reactor flow for premature cleanout. MTBF= 11 days MTTR = 1 day

System Leakage - Thermal and mechanical stress leaks would cause reactor shutdown for resealing. MTBF = 180 days MTTR = 1 day

Instrument Failure - Sensitivity of electronic parts causing shutdown to replace. MTBF = 75 days MTTR = 1 day

4. $A\ I = \frac{11}{22} \times \frac{180}{181} \times \frac{75}{76} = .8996$

B. Hexane Wash and Recovery Subsystem

1. Equipment and Function

The hexane wash and recovery system is designed to dissolve any decaborane remaining in the reactor loops, filter any entrained polymer, vacuum distill the hexane for recycle and recover crystalline decaborane.

The hexane is pumped from drums to the hexane hold tank (35241). The solvent is then pumped (41237) to fill the reactor loops then pumped through the borane polymer filter back to the hold tank. When the hold tank is saturated with B10, it is pumped to the wash system kettle (36204). The hexane is then distilled through a condenser (31205), recovery receiver (35214) and cold trap (35215) before the vacuum pump (32201). Non-condensables are exhausted into the vent header. The recovered hexane is pumped (41217) back to the hexane hold tank. After 100 lbs. of B10 is recovered raw materials R1 and R2 are added to the still kettle to prepare a batch to feed to the R3 Reactor.

2. Criticality

The hexane wash system is necessary to maintain efficient operation in the B10 Reactor Loops. The minimum equipment necessary to complete the washout is a drum pump to pump the hexane to the head tank. From there it can gravity flow into the reactor loops and to the process drain tank with some loss of B10 (about 2% of production). Potential modes of failure in this

system (mostly leakage) can be repaired with little loss of production. The hexane recovery system will operate less than 2% of the time and repairs can be made with no loss of production during the normal downtime on the still.

3. Potential Modes of Failure - Cause & Effect - Probability

System Leakage - Chemical and mechanical stress causing mechanical seal failure or other seal failure may delay washout or distillation.

MTBF - 180 days MTTR 8 hr. Not critical - No lost production.

4. A I = 1.00

C. Decaborane Dissolver - Filter Subsystem

1. Equipment and Function

The Dissolver Filter System receives decaborane from the product hoppers, forms a solution with R1 and R2 and filters the BH Polymer from this solution as the feed for an R3 Reaction Batch.

Decaborane is weighed into the dissolver (36202) as a dry powder. R1 and R2 are added through measuring pots (35208, 35209) and the kettle is heated to 100°F. with steam in the jacket and agitated. The solution is pumped (41231) through the dissolver filter (45205) into the dissolver surge tank (36210). The filter is back flushed with methanol-acetone which flows to the process drain tank.

2. Criticality

Since all of the decaborane produced flows through dissolver system, it is the most critical in the B10 area. It is buffered from the front by the large holding capacity of the product receivers and from the back by the dissolver surge tank, capable of holding a full dissolver batch. The system will be in mechanical operation about one hour per day and probable failures can be corrected in less than 24 hours. The system will have a high availability.

3. Potential Modes of Failure - Cause & Effect Probability

Seal Leakage - Thermal and mechanical stress

causing seal leaks would delay processing while being repaired. MTBF 200 days MTTR 8 hrs.

Pump Failure - Mechanical wear causing poor pump performance MTBF = 300 days MTTR 1 day

4. $A\ I = \frac{200}{200.33} \times \frac{300}{301} = .995$

D. R-3 Reactor Subsystem

1. Equipment and Function

The R-3 Reactor is designed to react the R-1/R-2/Decaborane solution with butyl sulfide to yield a complex which will react with 1 octyne in the NHC Reactor.

The filtered dissolved decaborane is gravity fed to the R-3 Reactor (36205) from an agitated surge tank (36210). R-3 is pumped (41209) from a drum through a measuring tank (35216) and into the R-3 Reactor. The reaction is exothermic and is controlled by cooling water circulating through the reactor jacket. Hydrogen is liberated in this reaction and is vented into the NHC vent header. The reaction is essentially complete in 24 hrs. and the low viscosity reaction mass is pumped (41218) into the NHC reactor feed pot (35207). Dissolved decaborane from the hexane recovery still is also reacted in the R-3 reactor as a blend with regular production decaborane. The wash product B10 has its own surge tank/feed pot (36212).

2. Criticality

The R-3 Reactor will be in service nearly continually due to the 24 hr. reaction time. It can be bypassed by using the NHC Reactor for the R-3 Reaction at approximately 50% equivalent downtime. Potential modes of failure (sealing and pumping problems) are easily corrected but may require a clean system for repair. Short-term loss is not critical to the production capacity. The low viscosity system will have good inherent availability.

3. Potential Modes of Failure - Cause & Effect Probability

Seal Failure - Thermal and mechanical stress leaks causing cleanout of this reactor to repair. MTBF = 360 days MTTR 1 day

Pump and Agitator Failure - Mechanical wear causing shutdown to replace rotating parts. MTBF = 3 yrs. MTTR 2 days

Instrument Failure - Sensitive electronic parts fail causing delay in processing. MTBF = 360 days MTTR 8 hrs.

4. $A\ I = \frac{360}{361} \times \frac{1080}{1082} \times \frac{360}{360.33} = .9945$

E. NHC Reactor Subsystem

1. Equipment and Function

The NHC Reactor System reacts the R-3 decaborane complex with refluxing 1-octyne and R-1 forming NHC. The excess solvents are then stripped and condensed. The NHC containing residue is then transferred to the planetary mixer.

R-1 and 1-Octyne are pumped from drums into separate measuring pots (35217, 35218) and fed into the reactor (36206). The R-3 complex is added from the feed pot (35207) over a period of two hours and the temperature is held at reflux. An NHC-sulfide complex is formed. After the reflux period, the solvents are vacuum stripped through a condenser (31206) waste receiver (35219) and cold trap (35220) before the vacuum pump (42204). Reaction waste is pumped (41219) to the process drain tank and non-condensables are vented to the NHC vent header. The NHC-sulfide complex residue and other by products are high viscosity and are nitrogen pressurized to the planetary mixer.

2. Criticality

The NHC Reactor is critical to the manufacture of the product NHC. There is no other piece of equipment that can accommodate the reflux and solvent stripping and the resultant high viscosity mass that remains. The unit is in operation 8 hours per day so that short term maintenance problems will not result in a significant loss of production. The unit is buffered by the NHC feed pot. With regular preventive maintenance and thorough cleanout, the inherent availability will be good.

3. Potential Modes of Failure - Cause & Effect Probability

Condenser Failure - Distillation of high boiling

liquids and foaming could foul condenser shutting down reactor for cleanout. MTBF = 180 days MTTR = 1 day

Instrument Failure - Electronic control systems malfunction necessitating shutdown to repair/replace. MTBF = 360 days MTTR 1 day

Vacuum System - Failure of rotating parts and vacuum leaks which cause reactor shutdown. MTBF = 360 MTTR 2 days.

Seal Failures - Valving and agitator seal leaks causing shutdown of reactor system to repair. MTBF = 180 days MTTR 1 day.

4. $A\ I = \frac{180}{181} \times \frac{360}{361} \times \frac{360}{362} \times \frac{180}{181} = .9808$

F. Planetary Mixer Subsystem

1. Equipment and Function

The planetary mixer is used to react the NHC Reactor residue with R-4, pyridine and remove the sulfide from the NHC. This product is extracted with pentane in the high work mixer. The pentane NHC is pumped to the wash tank and the residue diluted and drained.

The NHC residue pressured from the NHC Reactor is fed directly into planetary mixer (45202) and pyridine is pumped (41210) through a measuring pot (35221) and fed slowly to the residue. After reaction, pentane is pumped (41204) from the storage tank through a measuring pot (35222) and into the mixer. After the mixed extraction period the agitator is shut off, the residue settled and the pentane layer is pumped off (41220) to the NHC wash tank. The extraction is repeated 4 times. The remaining residue is thinned with toluene, pumped (41205) from storage through the toluene measuring pot (35223) and the thinned mass is pumped to the process drain tank.

2. Criticality

The planetary mixer is critical to the production capability of NHC. It is the only piece of equipment that can perform the extraction efficiently. This burden could possibly be performed inefficiently in the NHC Reactor with loss of yield due to poor agitation and production loss by preventing continued NHC reactions. The maintenance requirements and costs on this mixer

could be high due to the heavy strain imposed by the high viscosity residue. The unit is in operation 7 hrs./batch so that preventive and minor repair maintenance can be performed without loss of production.

3. Potential Modes of Failure - Cause & Effect Probability

Agitator bearing failure. High viscosity residue causing excessive bearing wear necessitating shutdown for replacement. MTBF = 180 days MTTR = 3 days.

Seal Failure - System leaks causing shutdown to repair/replace MTBF = 180 days MTTR = 1 day

Instrument Failure - Sensitive electronic parts fail shutting down mixer to replace. MTBF = 360 days MTTR = 1 day.

4. $A\ I = \frac{180}{183} \times \frac{180}{181} \times \frac{360}{361} = .9755$

G. NHC Wash Subsystem

1. Equipment and Function

Pentane - NHC from extraction is washed with two salt and two caustic washes to break down any non-NHC higher borane molecules. The washed pentane-NHC is pumped to the NHC purification kettle.

Pentane is pumped into the NHC wash tank (36208) in four extraction cuts. It is then washed with caustic/caustic/salt/salt solutions. 50% caustic is pumped (4121) from a drum into the caustic dilution tank (36209) where it is diluted with water. This 8% solution is transferred (41221) to a measuring pot (35225). It is gravity fed into the wash tank, agitated, settled then drained to the aqueous drain tank. The pentane layer is recycled to the wash tank through a hold tank (35238) and pump (41234). Dry salt is weighed into the salt dilution tank (36207) and diluted with water. This 5% solution is pumped (41222) through a measuring pot (35226) and gravity fed to the wash tank. The wash procedure is the same. After the four washes, the pentane layer is pumped (41223) to the NHC purification kettle.

2. Criticality

The wash system removes many impurities from the pentane extract which can be removed in the final distillation step. However, this procedure makes the

vacuum distillation much more difficult to control due to gas formation and higher residue formation. The wash process takes about 5 hrs. and the probable modes of failure (sealing problems) are easily corrected in the normal downtime so this unit should have excellent availability.

3. Potential Modes of Failure - Cause & Effect Probability

Pump and Agitator Failure: Wearout of rotating parts causing shutdown to remove and replace. MTBF = 2 yrs. MTTR = 2 days

4. $A\ I = \frac{730}{732} = .997$

H. NHC Purification System

1. Equipment and Function

The NHC Purification Atmospheric Distillation Still strips and recovers pentane from the washed pentane extract.

The washed pentane extract is pumped into the NHC purification kettle (35227) which is heated with low pressure steam. The pentane vapors flow through a packed column, are condensed (31207) and the stream split equally to flow to reflux and to the receiver (35239). After the bulk of the pentane is stripped, it is pumped (41235) back to storage. The pot residue is pumped (41246) to the vacuum distillation unit.

2. Criticality

This unit performs a distillation that could be handled by the final vacuum distillation unit at a reduced efficiency and some loss of production and loss of pentane. The batch time in the still is five hrs. and this is the simplest distillation due to a one solvent fraction, atmospheric pressure, and little or no foaming in the operation. The column packing may require regular cleanout but this can be accomplished with no loss of production. This system will have high availability.

3. Potential Modes of Failure - Cause & Effect Probability

Control Instrument Failure - sensitive electronics

failure controlling distillation resulting in shutdown to repair or replace. MTBF = 180 days MTTR = 1 day.

Seal Failure - Mechanical and chemical stress causing leaks resulting in shutdown of operation. MTBF = 360 days. MTTR = 1 day

Pump Failure - Rotating parts wearout causing shutdown to remove and repair MTBF = 2yrs. MTTR = 2 days.

Condenser Pluggage - Solids and tar buildup during batch causing shutdown before batch completion to cleanout. MTBF = 270 days. MTTR = 1 day.

4. $A \cdot I = \frac{180}{181} \times \frac{360}{361} \times \frac{730}{732} \times \frac{270}{271} = .985$

J. NHC Vacuum Distillation Subsystem

1. Equipment and Function

The vacuum distillation unit distills the residue from the atmospheric still into four fractions, one of which is high purity NHC product.

The vacuum distillation unit (47210) receives the stripped residue from the atmospheric still and the forecut from the previous batch is pumped (41236) into the still. The absolute pressure is gradually lowered and the temperature of the electrically heated still pot raised. The overhead vapors pass through the packed column, are condensed and refluxed and the first cut taken is pentane and volatile byproducts which is pumped (41224) to the process drain tank. The second cut, or forecut, is low purity NHC and is recycled in the subsequent batch. The third cut, the NHC product is pumped (41225) off for packaging. Toluene is measured (35224) into the still and the thinned residue is pumped to the drain tank.

2. Criticality

This distillation has proven to be difficult on the pilot plant scale. Since this is the final step in the process and determines the purity and yield of the batch production, efficient operation is mandated. Batch cycle time is uncertain, possibly 16 hrs. Two units are to be installed, the second serving as a spare or for redistillation of off purity material. High main-

tenance is expected due to the high vacuum service. Regular cleanout and preventive maintenance will provide acceptable availability in a single unit and high availability in the parallel units.

3. Potential Modes of Failure - Cause and Effect Probability

Low Purity NHC - Poor operational control resulting in off spec NHC requiring redistillation. MTBF = 15 days. MTTR = 1 day.

Column Buildup - Buildup of solids and tars in column requiring shutdown to dissolve and clean MTBF 90 days - MTTR = 1 day

Vacuum System - Mechanical wear in vacuum pump will not permit full vacuum (.5 mm Hg) causing shutdown to rebuild. MTBF = 180 days MTTR = 3 days.

Instrumental Failure - Control instruments fail requiring shutdown to repair MTBF = 180 days MTTR = 1 day.

Piping System Leaks - Thermal and mechanical stress leaks causing shutdown to repair MTBF = 180 days. MTTR = 1 day.

4. $A\ I\ (1\text{ unit}) = \frac{15}{16} \times \frac{90}{91} \times \frac{180}{183} \times \frac{180}{181} \times \frac{180}{181} = .902$

$A\ I\ (\text{parallel}) = 1.-(1.0-.902)^2 = .990$

K. Waste Disposal System - Incinerator Subsystem

L. Equipment and Function

The incinerator receives all of the process waste gases and liquids, oxidizes them completely and precipitates and collects the particulates formed for disposal as dry solids.

Gaseous and vapor streams from the process vent headers pass through three seal pots (35236, 35257, 35258) which maintain a slight positive pressure on the vents. These feed directly to the incinerator (44204). A fourth seal pot (35237) provides pressure relief for the three seal pots and feeds directly to the emergency flare. Waste organic liquids from the process drain tank (35232) are pumped (41229) into the incin-

erator process feed tank (35233). This liquid is pumped (41230) to the incinerator on an intermittent basis to compensate for reduction in flow of organic vapors. The waste aqueous stream is pumped (41243) from the drain tank (35250) to the feed tank (35251). This is pumped (41244) on a continuous basis into the incinerator to react with the oxidizing boron species. The dirty waste gases are quenched with water sprays and particulates are filtered through the bag house. The collected solids are drummed for disposal. The incinerator operation is automatic to minimize the use of auxiliary fuel.

2. Criticality.

The incinerator oxidizes all of the toxic and polluting waste materials from the process and converts them into innocuous materials. Production should stop if the incinerator is shut down. The emergency flare will handle the process vapor flow but all efforts must be made to exclude volatile boranes from this stream. The B10 area must be shut down as well as most of the NHC area. The incinerator is being designed to be as reliable and maintainable as possible. The baghouse is compartmentalized so that one section can be isolated if there is bag failure. Many operational parts are replaceable with the unit in restricted operation. Refractory problems are probable with the glass forming boron oxides. Relatively low (1600° F) furnace temperature should slow any refractory degradation. Auxiliary equipment (tanks, pumps, seal pots) will have high availability with short term loss not critical and easily repairable.

3. Potential Modes of Failure - Cause & Effect Probability

Refractory Failure - Occasional heating and cooling cycles and chemical attack gradually deteriorate refractories causing shutdown to rebuild. MTBF = 6 yrs. MTTR = 18 days.

Filter Bag Failure - Mechanical wear and thermal degradation cause lower collection efficiency requiring shutdown to replace bags. MTBF 240 days. MTTR = 3 days

Instrumental Control - Malfunction of controls causing shutdown to repair. MTBF = 180 days MTTR = 1 day.

Feed Pump Failure - Mechanical wear and chemical stress failures causing process shutdown after drain tanks fill. MTBF = 180 days
MTTR = 1 day

4. $A\ I = \frac{2160}{2175} \times \frac{240}{243} \times \frac{180}{181} \times \frac{180}{181} = .970$

L. Utilities Systems

1. Equipment and Function

The process utilities provide the support for the NHC production equipment.

a. Electric power is purchased from Pennsylvania Power Co. and is available as 120 V. single phase or 460 V. three phase. Electricity is critical to the operation of the plant, but is highly reliable.

b. Process water is purchased from Evans City and is held in two 1/2 million gallon reservoirs. Pressure is provided by a jockey pump and a diesel fire pump if electricity is lost.

c. Natural gas is purchased from the Peoples Natural Gas Co. and is piped from the existing Callery plant. It is critical only as pilot fuel for the flare and cylinderized gas (propane) could be substituted for short term use. It is highly reliable. All other fuel consuming equipment is operated on #2 fuel oil.

d. 50 psig steam is provided by the electrically heated process boiler (44202A) and the oil fired building heat boiler (44202B). These are serviced by the water treatment unit (47201), the boiler chemical treatment unit (47202), the deaerator (47204) and the condensate return unit (47203). Dual systems provide extremely high reliability. Fuel oil is backed up by natural gas.

e. Nitrogen, used for inerting the process and equipment, will be purchased and stored as a liquid in the nitrogen storage system (47207). Since nitrogen supply is extremely critical to the safety of the operation, the liquid storage will be backed up by a high pressure cylinder manifold system for the unlikely event of the liquid system failure. Availability must be 100%. 50 psig nitrogen gas will be generated from the liquid.

f. 100 psig. instrument air and the breathing air are provided by the dual air compressors (42203 1 and 2) and instrument air dryer (47206). Instrument air supply is critical to the plant operation since all air operated process valves should fail in a safe position if air is lost. Safe position will normally be non-operational. High availability is inherent in this system with proper maintenance. Maintenance requirements will be low.

g. Cooling water and chilled cooling water provide the heat transfer necessary to efficiently operate the processes. The cooling tower (44203) provides all of the cooling for the plant, with the exceptions of the B10 reactor condenser legs and the pentane condenser, which are cooled by the chilled cooling water system (44201). Loss of chilled water would not be critical but would cause decreased yields in decaborane production and reduced pentane recovery. The loss of all cooling water would necessitate a shutdown, but reliability is excellent and probable failures (system sealing) are quickly and easily repaired.

2. <u>Criticality</u>

The criticality of each individual system has been discussed above. Failure of electricity supply would be the most critical item, but there can be no backup system. Nitrogen is also extremely critical to the operability of the plant but the liquid/vapor supply system will provide the necessary reliability. The dual air compressors provide excellent reliability with partial load shifting in the event of failure of one unit. Production may be slightly curtailed. The cooling water is recirculated by two pumps feeding a common line. Loss of one pump would not cause significant production delays. The overall availability of the critical utilities will be very good.

3. <u>Potential Modes of Failure - Cause & Effect Probability</u>

Steam, water, gas and nitrogen should not fail in the 15 year economic life of the plant.

Electricity - Loss from utility company or insulator ground fault would shut down plant. MTBF = 90 days MTTR = 12 hrs.

Compressed Air Failure - Wearout of rotating parts causing shutdown to repair. MTBF = 4 yrs. MTTR = 2 days

Cooling Water - Failure of pumps resulting in shutdown to repair MTBF = 360 days. MTTR = 1 day.

4, $A\ I = \frac{90}{90.5} \times \frac{1440}{1442} \times \frac{360}{361} = .990$

APPENDIX D

RELIEF AND VENT SIZING CALCULATIONS

SUBJECT Control valve sizing

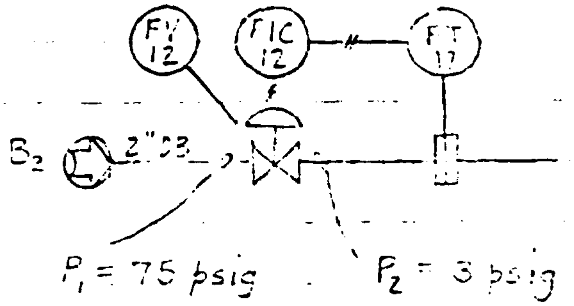
CONTRACT NO. 2737
SHEET NO. [illegible]
AREA NO. [illegible]
ITEM NO. FV-12
DRAWING NO.

MADE BY [illegible] DATE [illegible]
CHECKED BY KEV DATE 4/7/77
APPROVED BY ______ DATE ______
APPROVED BY ______ DATE ______

C60-R1

PAGE 1 OF 3

CALCULATION



.75 #/h
x/3 = ~9.75 29/21 SCFh
10.5 SCFH
1.5 DSCFH
.105 MSCFH
.0105 MSCFH

rule say .003

Data

Fluid: Diborane (B_2) Gas

Mol. wt. = 27.7

P_1 = 90 psia

P_2 = 18 psia

W = 0.75 $\frac{lbm}{hr}$

T = ambient = 530°R

Equation for valve sizing[1]:

$$F_P C_v = \frac{W}{19.3 P_1 Y}\sqrt{\frac{T Z}{X M}}$$

Where; $X = \frac{P_1 - P_2}{P_1} = 0.8$

assume 1. choked flow → Y = 0.67

2. ideal gas → Z = 1.0

$$F_P C_v = \frac{0.75}{19.3(90)(0.67)}\sqrt{\frac{530(1)}{0.8(27.7)}} = .0032$$

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SUBJECT

MADE BY ____ DATE ____
CHECKED BY ____ DATE ____
APPROVED BY ____ DATE ____
APPROVED BY ____ DATE ____

CONTRACT NO.
FLOW SHEET NO.
AREA NO.
ITEM NO.
DRAWING NO.

660-R1

CALCULATION

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Check result using equations from Masoneilan Handbook for control valve sizing.

Critical flow if $\Delta P \geq 0.5\, C_f^2\, P_1$

$C_f = 1.0$ max., $\Delta P = 72 > 0.5 P_1 = 45$ ∴ critical flow.

$$C_v = \frac{W}{2.8\, C_f\, P_1 \sqrt{G_f}} = \frac{0.75}{2.8(1)(90)\sqrt{1}} = .003$$

Manufacturer's of low C_v valves :

1. Research
2. ~~Fisher~~
3. Hammel-Dahl
4. Jordan ✓

Assume Jordan 1/4" valve. H trim $C_v = .006$

$$F_p = \left[\frac{\sum K\, C_d^2}{890} + 1\right]^{-1/2} \approx 1.0$$

where: $C_d = \dfrac{C_v}{d^2} = \dfrac{.006}{(1/4)^2} = .096$

$$\sum K = 1.5\left[1 - \left(\frac{d}{D}\right)^2\right]^2 = 1.45$$

$$\frac{d}{D} = \frac{1/4"}{2"} = 0.125$$

SUBJECT ______________________

MADE BY ______ DATE ______
CHECKED BY ______ DATE ______
APPROVED BY ______ DATE ______
APPROVED BY ______ DATE ______

CONTRACT NO. ______
FLOW SHEET NO. ______
AREA NO. ______
ITEM NO. ______
DRAWING NO. C60-R1

CALCULATION

with $F_p C_v \sim 0.006$, valve capacity is —

$$W = 19.3\ F_p C_v P_1 Y \sqrt{\frac{x M}{T Z}} = [illegible]1.43\ \frac{lbm}{hr}$$

% of max. flow = $\frac{[illegible]}{[illegible]} \times 100 = [illegible]3\%$

SUBJECT ______

MADE BY RPT DATE ______
CHECKED BY KEV DATE 4/5/77
APPROVED BY ______ DATE ______
APPROVED BY ______ DATE ______

CONTRACT NO. 2739
FLOW SHEET NO. 113-225
AREA NO. E1
ITEM NO. FI-26
DRAWING NO. 660-8

PAGE 1 OF ______

CALCULATION

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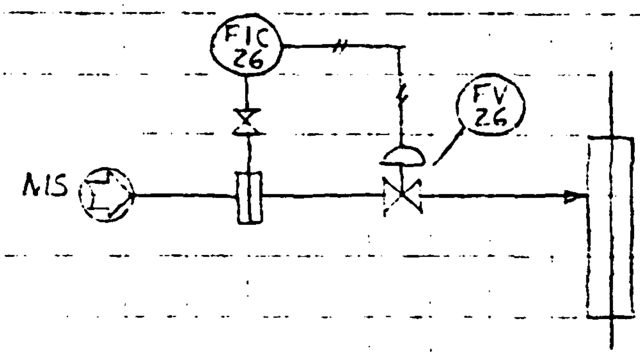


Data —

Steam (saturated)

$P_1 = 100$ psig $= 115$ psia

$P_2 < \frac{1}{2} P_1$ ∴ critical flow

$W = 75 \frac{lbm}{hr}$ (Process estimate C. Kowalski 3-31-77)

Equation for sizing

$$F_p C_v = \frac{W}{2 P_1 \sqrt{X_{TP}}}$$

where $X_{TP} = X_T$, if no reducers

$X_T = 0.84\, C_f^2 = 0.54$

assume $C_f = 0.8$ minimum

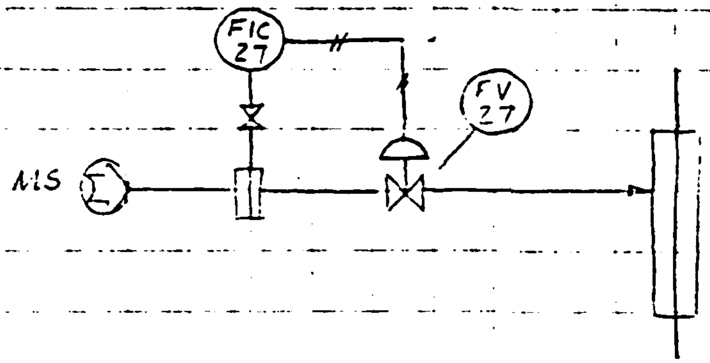
$$F_p C_v = \frac{75}{2(115)\sqrt{0.54}} = 0.44$$

SUBJECT

MADE BY | DATE
CHECKED BY (initials) | DATE 4/11/77
APPROVED BY | DATE
APPROVED BY | DATE

CONTRACT NO. 2739
FLOW SHEET NO. 114-203
AREA NO. NHC
ITEM NO. FV-27
DRAWING NO. 660-R1
PAGE 1 OF

CALCULATION



Data

Steam (sat.)

$P_1 = 100$ psig

$P_2 < 1/2\, P_1$ critical flow

$W = 75 \frac{lbm}{hr}$

Calculation same as for FV-26

$F_p C_v = 0.44$

SUBJECT: Ball Valve Sizing Notes

CONTRACT NO. 2739
FLOW SHEET NO.
AREA NO.
ITEM NO.
DRAWING NO. 660-R2

MADE BY: R. Vance DATE: 4/1/77
CHECKED BY: [illegible] DATE: [illegible]
APPROVED BY: DATE:
APPROVED BY: DATE:

PAGE ____ OF ____

CALCULATION

(1) HV-1A, per 125-202, water flow is 40 GPM. Looking at Crane table, 1½" is best size for 40 GPM.; knowing Thones the pipe is bound to be 1½ at least.

(2) HV-2 pipe purge - I picked ½ because it seems ok.

(3) HV-3 thru 11 drum purge power - per 125-203, flow is 5 SCFM
5 SCFM × ~~24~~ 60 = ~~120~~ 300 SCFH = ~~.120~~ 0.30 MSCFH
from rule, @ 5 # dP; Cv = 0.09 .42
pick ½ inch because that is as small as one can get (⅜, ¼ & ⅛ valves can be had, but are no cheaper and can not be hung up in piping economically.)

AP THRU ½ PIPE @ 5 SCFM IS 0.115 PSI/100' @ 100 PSIG INLET AIR [illegible]

(4) HV-11 & HV-12 Same as (2)

6

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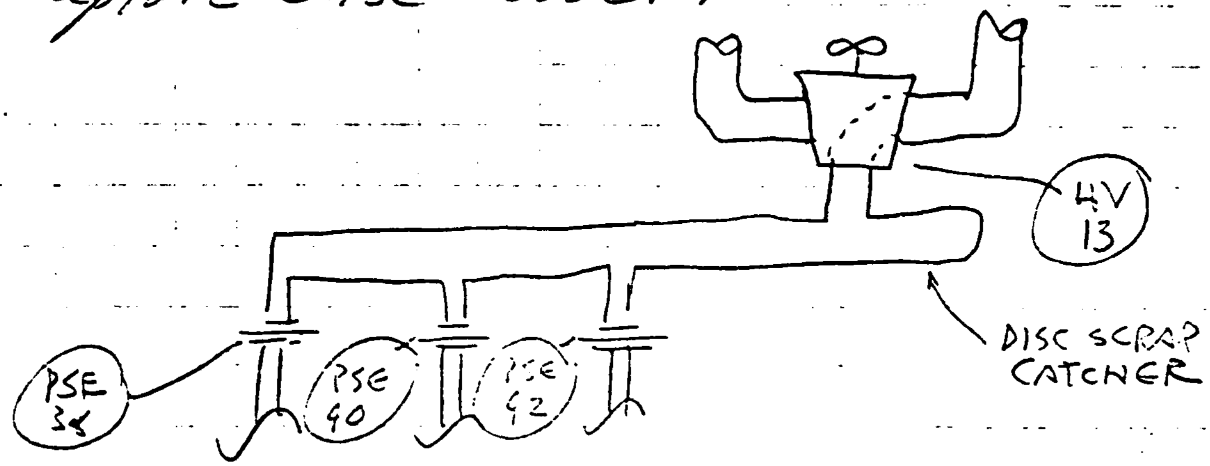
SUBJECT DIVERTER FOR RUPTURE DISCS

CONTRACT NO. 2739
FLOW SHEET NO.
AREA NO.
MADE BY [illegible] DATE [illegible]
ITEM NO. HV-13
CHECKED BY ANC DATE 7-28-77
DRAWING NO. 660-R5
APPROVED BY DATE
APPROVED BY DATE

CALCULATION

Size 3 way diverter for reactor rupture disc header:



① Problem is that area of internal pathway must not be reduced by restraint of HV-13. Find effective area of each disk.

② Disc calculation was done 3 times by 3 people:

(2a) W.C. says $d = 0.99''$, pick $1\frac{1}{2}$ disc
R.T. says $d = 0.734''$, pick $1\frac{1}{2}$ disc
W.S.L. says $d = 1.049$ (assumed) pick 1" disc.

(Note - 1" disc is not available at low settings
∴ Min is $1\frac{1}{2}$")
pick a 2" disk because that matches pipe size and is as large as possible (reactor outlet is 2").

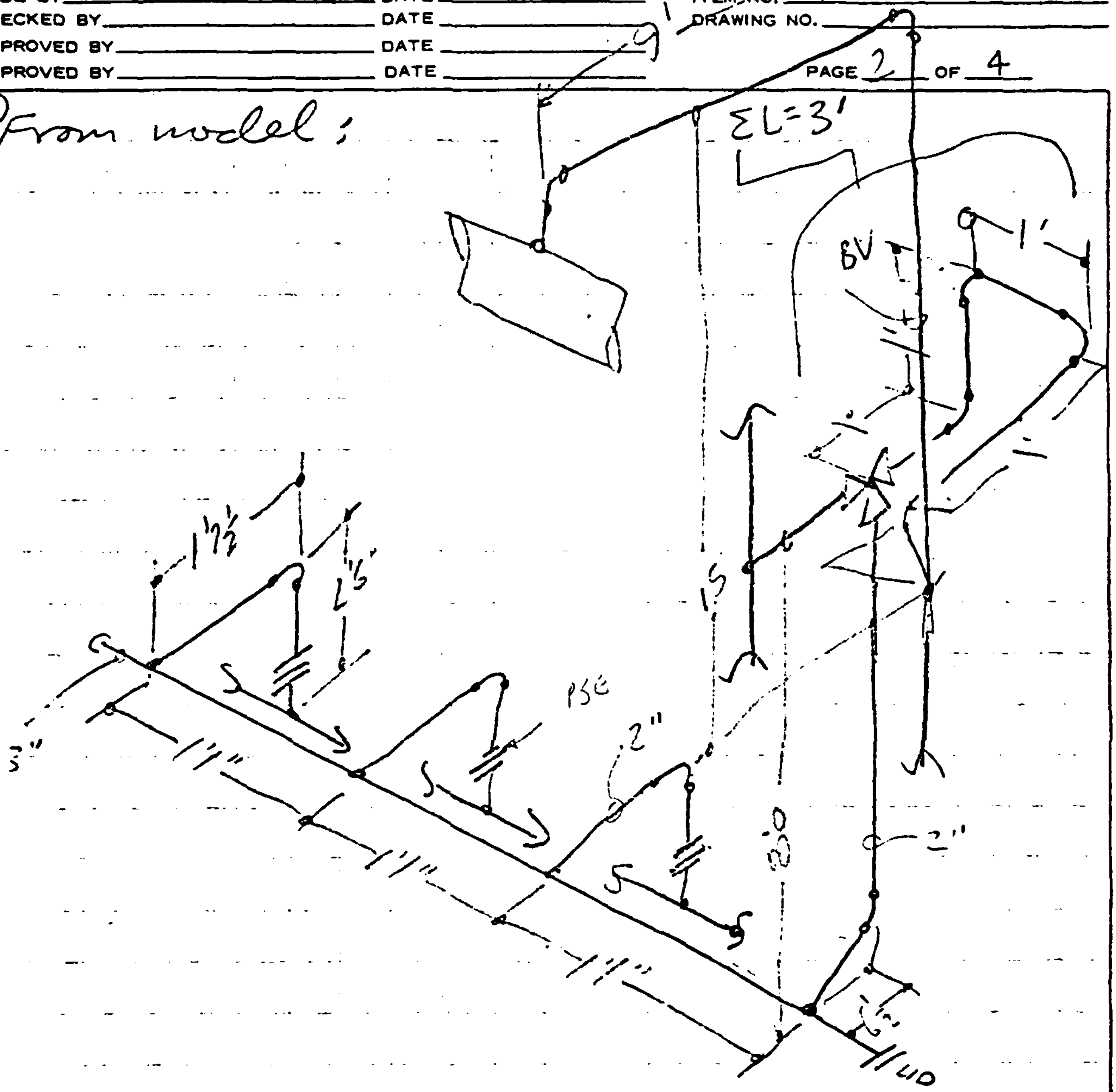
SUBJECT

MADE BY ____ DATE ____
CHECKED BY ____ DATE ____
APPROVED BY ____ DATE ____
APPROVED BY ____ DATE ____

CONTRACT NO. ____
FLOW SHEET NO. ____
AREA NO. ____
ITEM NO. HV-13
DRAWING NO. ____

CALCULATION

③ From model:



8

SUBJECT ______

MADE BY ______ DATE ______
CHECKED BY ______ DATE ______
APPROVED BY ______ DATE ______
APPROVED BY ______ DATE ______

CONTRACT NO. ______
FLOW SHEET NO. ______
AREA NO. ______
ITEM NO. HV-13
DRAWING NO. ______

CALCULATION

4

		L/D each	ΣL/D	K each
2" pipe	= 40.5 ft	–	–	–
3" pipe	= 3.25 ft	–	–	–
2" disc	= 1 ea	–	–	0.5
2" el	= 6 ea	30	180	
2" 45°s	= 2 ea	16	32	
3x3x2 tee, flow from branch,	= 1 ea	60	60	
3x3x2 teel flow to branch	= 1 ea	60	60	
2x2x2 tee flow from branch	= 1 ea	60	60	
entrance to big header	= 1 ea			1.0
3 way valve, thru branch		140	140	
Σ :			532	1.5 K

from chart A-31, 40.5 ft of 2" = 9.5 K
" " 3.25 ft of 3" = 0.2 K
532 L/D of 2" = 10.5 K

∴ ΣK = 16.7

5 from procedure 20, rev supplement 1/31/74

$$W = 1891\, Y d^2 \sqrt{\frac{\Delta P}{K \bar{V}}}$$

P_1 = 16.5 psig + 14.7 = 31.2 PSIA
P_2 = ~ atmos + 12" say 15.2 PSIA
∴ ΔP = 16 psi

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SUBJECT

CONTRACT NO.
FLOW SHEET NO.
AREA NO.
ITEM NO. HV-13
DRAWING NO.

MADE BY DATE
CHECKED BY DATE
APPROVED BY DATE
APPROVED BY DATE

CALCULATION

$\therefore \frac{\Delta P}{P_1} = \frac{.16}{31.2} = 0.513$

from chart, for $K \approx 17$ & $\frac{\Delta P}{P_1} = 0.513$, $Y = 0.82$
(crane page A-22)

d^2 for 2" Sch 40 = 4.272

$\bar{V}$ 2.582 $ft^3/\#$, from PSE calculations

$\therefore w = 1891\, Y d^2 \sqrt{\frac{\Delta P}{K \bar{V}}}$

$= 1891 \times 0.82 \times 4.272 \sqrt{\frac{0.513}{16.7 \times 2.582}}$ .16 .4635 #/h

$\sqrt{.0119}$

.109 $= \cancel{722}\#/h$

per OK, w = 658.27; per R.T., w = 502;
per WSL, w = 659 #/h.
worse case is 659 #/h for one reactor loop
or 659 x 3 = 1977 #/h for 3, without
x.3 factor for spray which was added
after the calculation was made.

1977 x 0.3 = 593 #/h

593 < 722 $\therefore$ 2" valve & piping is OK

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SUBJECT

MADE BY ______ DATE ______

CHECKED BY [signature] DATE 4/11/77

APPROVED BY ______ DATE ______

APPROVED BY ______ DATE ______

CONTRACT NO. 2739

FLOW SHEET NO. [illegible]

AREA NO. 2

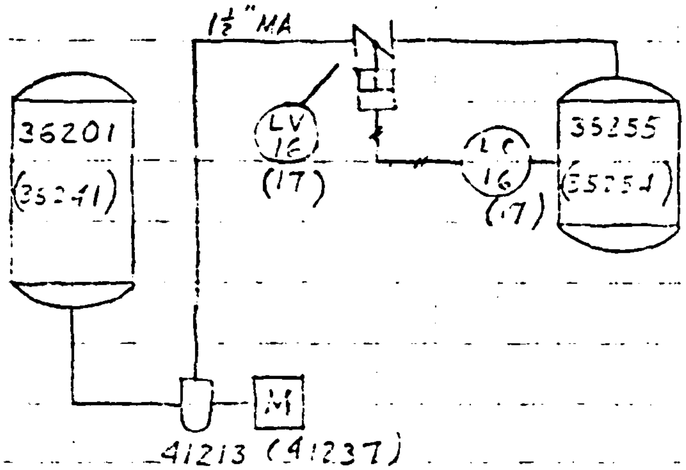
ITEM NO. LV-16, LV-17

DRAWING NO.

660-R3

PAGE 1 OF ______

CALCULATION



On-off service

Data for LV-16 —

Methanol-Acetone solution

$G = 0.8$

$\Delta P = 5$ psi assumed (no piping info)

$q = 20$ gpm

$$F_p C_v = q\sqrt{\frac{G}{\Delta P}} = 20\sqrt{\frac{0.8}{5}} = 8$$

Data for LV-17

Hexone $G = 0.65$

$\Delta P = 5$ psi (no piping info)

$q = 20$ gpm

$$F_p C_v = 20\sqrt{\frac{0.65}{5}} = 7.2$$

pick 1" Ball

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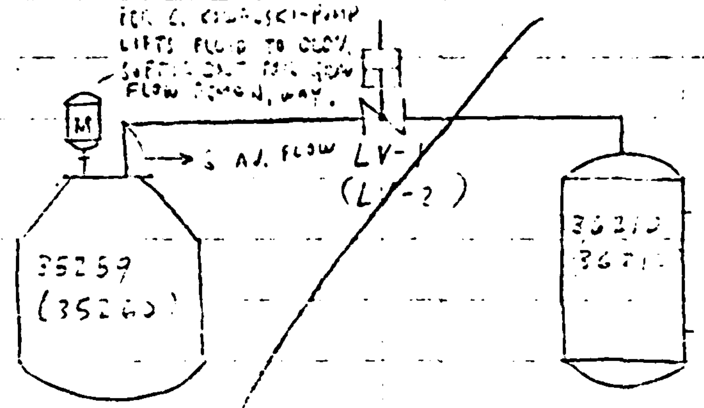
SUBJECT

CONTRACT NO. [illegible]
FLOW SHEET NO. [illegible]
AREA NO. [illegible]
ITEM NO. LV-1 2
DRAWING NO.

MADE BY DATE
CHECKED BY [illegible] DATE 4/11/77
APPROVED BY DATE
APPROVED BY DATE

PAGE 1 OF

CALCULATION



Data LV-1 and 2

Dissolver product

$G = 0.8$

ΔP 5 psi

$q = 10$ gpm

$$C_v = q\sqrt{\frac{G}{\Delta P}} \qquad 4$$

wrong - these services are now changed to 1½" full line size - gravity flow at very little ΔP.

Spec in 1½ s.s., flanged.

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SUBJECT Sizing Valves

MADE BY R.Z.U. [illegible] DATE 4/2/77
CHECKED BY AWC DATE 4-18-77
APPROVED BY ______ DATE ______
APPROVED BY ______ DATE ______

CONTRACT NO. 2739
FLOW SHEET NO. ______
AREA NO. ______
ITEM NO. TV-6
DRAWING NO. 660-R4
PAGE 1 OF 2

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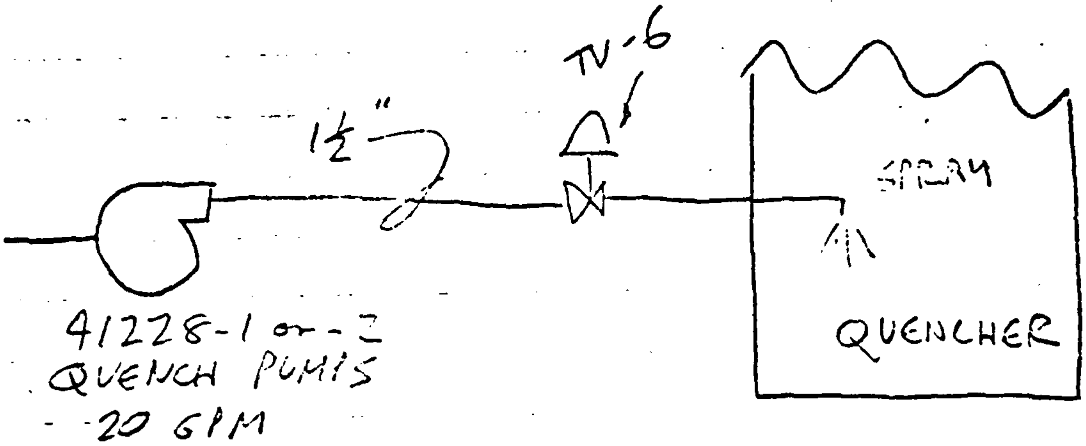
CALCULATION

SIZE TV-6



ONLY DATA IS THAT QUENCH PUMPS ARE TO FLOW 20 GPM. NO INFO ON QUENCHER SPRAYS OR PIPING

PER H. HUBER - WE ARE TO MAKE ASSUMPTIONS TO GET ALL MATTER OUT PRELIMINARY.

∴ ① ASSUME W.H.L. KNOWS THAT 20 GPM IS A REASONABLE MAX NUMBER.

② ASSUME THAT THE SPRAYER NEEDS 15 TO 30 PSI TO ATOMIZE, WHICH IS NORMAL ∴ PICK VALVE ΔP = ~1/3 SYSTEM ΔP = 10 PSI (we can make this assumption reality by telling MECH. to allow 10 PSI when they write the pump final req.)

SUBJECT

CONTRACT NO. 2739
FLOW SHEET NO.
AREA NO.
ITEM NO. TV-6
DRAWING NO.

MADE BY ______ DATE ______
CHECKED BY ______ DATE ______
APPROVED BY ______ DATE ______
APPROVED BY ______ DATE ______

PAGE 2 OF 2

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CALCULATION

(3) 20 GPM makes a line drop of only 1.3 PSI/100 ft of 1½" ∴ neglect line drop. (Per Crane table)

$$\therefore \quad \beta C_v = GPM\sqrt{\frac{S}{\Delta P}} = 20\sqrt{\frac{1}{10}}$$

$$= 20 \times .316 = 6.3$$ ✓

Reducing a ¾ trim in a 1½ valve:

$$C_D = \frac{C_v}{D^2} \approx \frac{25}{2.25} = 3.5$$ ✓

$$\frac{d}{D} = \frac{.75}{1.5} = 0.5$$ ✓

From table III ... Fβ ≈ .8

$$\therefore C_v \text{ required} = \frac{6.3}{.8} = 7.9$$ ✓

SUBJECT

MADE BY DATE

CHECKED BY DATE

APPROVED BY DATE

APPROVED BY DATE

CONTRACT NO.

FLOW SHEET NO.

AREA NO.

ITEM NO.

DRAWING NO.

628-RL

PAGE ___ OF ___

CALCULATION

PSV-3 ON R-3 REACTOR 36205

PSV-9 ON NHC REACTOR 36206

"SENTINEL" SAFETY VALVES SET AT LOWER PRESSURE THAN RUPTURE DISC

DESIGN PRESSURE 36205 = 15 PSIG @ °F

" 36206 = FV & 30 PSIG @ 366°F

SEE RUPTURE DISC CALCULATION PSE-4, 8.

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SUBJECT [illegible]

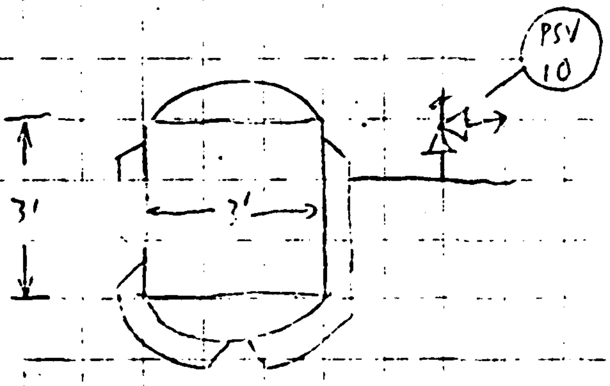
CONTRACT NO. 2739
FLOW SHEET NO. [illegible]
AREA NO.
ITEM NO. PSV-10
DRAWING NO. 628-R1

MADE BY [illegible] DATE [illegible]-77
CHECKED BY [illegible] DATE 5/[illegible]/77
APPROVED BY DATE
APPROVED BY DATE

PAGE 1 OF 2

CALCULATION

BASIS: Fire exposure to jacket full of water



36206
NHC REACTOR

JACKET DESIGN CONDITIONS:
FV & 150 PSIG @ 366°F

$P_1 = 1.2 \times 150 + 14.7 = 194.7$ PSIA

S = SURFACE AREA EXPOSED TO FIRE = $1.66 \frac{\pi D^2}{4} + \pi D H$ = 5.4 [illegible] ft^2

Q = RATE OF HEAT ABSORPTION = $0.3 \times 21{,}000\,(S)^{0.82}$ = ~~[illegible]~~ 117,[illegible] $\frac{BTU}{hr}$

L = HEAT OF VAPORIZATION OF WATER AT 195 PSIA = 84[illegible] $\frac{BTU}{lb}$

W = PSV-10 DISCHARGE CAPACITY = $\frac{Q}{L}$ = 153.5 $\frac{lbm}{hr}$

A = ORIFICE AREA = $\frac{W}{50 P_1}$ = 0.'5 [illegible]

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INSTRUMENT WORK SHEET NO. 9.1

RELIEF VALVE CALCULATION
GAS OR VAPOR

(See Engineering Procedure No. 20)

CONTRACT NO.: 2739
ITEM NO.: PSV-10
FLOW SHEET NO.: 114-701
MADE BY: RPT DATE: 4-25-77
CHECKED BY: ______ DATE: ______
SHT-2 of 2

BASIS OF SIZING: Critical Velocity.
FIRE EXPOSURE TO JACKET FULL OF WATER.

GENERAL

Vessel Item Number & Description: 36206 NHC REACTOR
Vessel Dimensions: Dia.: 3 Ft. Straight Shell: 3 Ft.
Design Pressure: JACKET PV @ 150 psig Design Temperature: 366 °F.
Insulation: NONE Volume: ______ Cu. Ft.

PROPERTIES OF CONTENTS

Fluid WATER CK = ______ d_v = ______ #/cu.ft. E = 0 BTU/Hr.
h = ______ BTU/Hr/Sq.Ft. K_{sh} = 1.0 L_v = 845 BTU/# M = ______
p = 150 psig P_1 = 195 psia T = 380+460 °R V = 0 gpm
Z = ______

CALCULATIONS

1. Wetted surface (Horizontal) $S = \pi D(.4D + .67L)$ = ______ sq. ft.
(Vertical) $S = \pi D(.25D + L)$ = 40 sq. ft.

		Fire Conditions P_1 = 1.2 x Design Press.	Heater Duty P_1 = 1.1 x Design Press.
2. Heat input rate = H	BTU/hr.	WATER CIRC. 0.3 x 440,000	[illegible]
3. Total heat input rate $Q = H + E$	BTU/hr.	132,000	
4. Vapor generation rate $W_1 = Q/L_v$	#/hr.	156	
5. Vapor displacement rate $W_2 = 8.02VD_v$	#/hr.	0	
6. Total discharge rate $W = W_1 + W_2$	#/hr.	156	
7. Steam: $A^* = \frac{W}{50P_1K_{sh}}$	sq.in.	.016	
8. Other Vapors: $A^* = \frac{W}{CKP_1}\sqrt{\frac{ZT}{M}}$	sq.in.		
9. Gases by volume: $A^* = \frac{SCFM\sqrt{ZTM}}{6.32CKP}$ (SCFM @ 14.7 psia and 60°F)	sq.in.		

10. Relief valve size required: .016 in² Selected: ______

*If ASME Code applies, divide A by 0.90.

SUBJECT

MADE BY

CHECKED BY DATE 5/3/77

APPROVED BY DATE

APPROVED BY DATE

CONTRACT NO.

FLOW SHEET NO.

AREA NO.

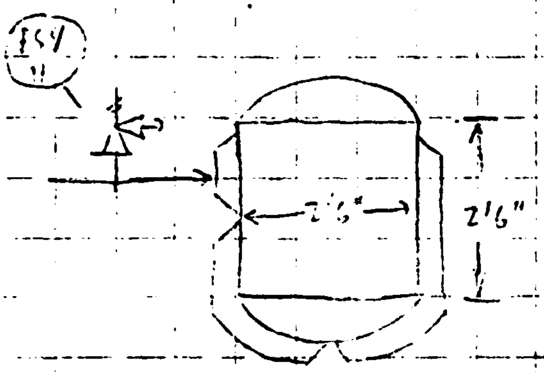
ITEM NO.

DRAWING NO. 628-R1

PAGE 1 OF 2

CALCULATION

BASIS: FIRE EXPOSURE TO JACKET FULL OF WATER



36205

R-3 REACTOR

JACKET DESIGN CONDITIONS;

100 PSIG @ [illegible] °F

$P_1 = 1.2 \times 100 + 14.3 = 134.3$ PSIA

S = SURFACE AREA EXPOSED TO FIRE = [illegible] + π D H = 27.8 ft²

Q = RATE OF HEAT ABSORPTION = $0.3 \times 21{,}000\ (S)^{0.82}$ = 96,262 $\frac{BTU}{HR}$

L = HEAT OF VAPORIZATION OF WATER AT [illegible] °F = 870 $\frac{BTU}{lbm}$

W = PSV-11 DISCHARGE CAPACITY = $\frac{Q}{L}$ = 110.5 $\frac{lbm}{HR}$

A = ORIFICE AREA = $\frac{W}{50\,P_1}$ = .016 in²

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INSTRUMENT WORK SHEET NO. 9.1

RELIEF VALVE CALCULATION
GAS OR VAPOR

(See Engineering Procedure No. 20)

CONTRACT NO.: 7737
ITEM NO.: [illegible]
FLOW SHEET NO.: [illegible]
MADE BY: [illegible] DATE: 4-25-77
CHECKED BY: ______ DATE: ______

Sheet 2 of 2

BASIS OF SIZING: Critical Velocity
FIRE EXPOSURE TO JACKET FILLED WITH WATER.

GENERAL

Vessel Item Number & Description: 36205 R-1 REACTOR
Vessel Dimensions: Dia.: 2½ Ft. Straight Shell: [illegible] Ft.
Design Pressure: JACKET [illegible] psig Design Temperature: [illegible] °F.
Insulation: — Volume: ______ Cu. Ft.

PROPERTIES OF CONTENTS

Fluid WATER CK = ______ d_v = ______ #/cu.ft. E = 0 BTU/Hr.
h = ______ BTU/Hr/Sq.Ft. K_{sh} = 1.0 L_v = 870 BTU/# M = ______
p = 100 psig P_1 = 135 psia T = ______ °R V = 0 gpm
Z = ______

CALCULATIONS

1. Wetted surface (Horizontal) $S = \pi D(.4D + .67L)$ = ______ sq. ft.
(Vertical) $S = \pi D(.25D + L)$ = [illegible] sq. ft.

		Fire Conditions P_1 = 1.2 x Design Press.	Heater Duty P_1 = 1.1 x Design Press.
2. Heat input rate = H	BTU/hr.	0.3 x 330,000	
3. Total heat input rate $Q = H + E$	BTU/hr.	98,[illegible]	
4. Vapor generation rate $W_1 = Q/L_v$	#/hr.	113	
5. Vapor displacement rate $W_2 = 8.02VD_v$	#/hr.	0	
6. Total discharge rate $W = W_1 + W_2$	#/hr.	113	
7. Steam: $A^* = \frac{W}{50P_1K_{sh}}$	sq.in.	.017	
8. Other Vapors: $A^* = \frac{W}{CKP_1}\sqrt{\frac{ZT}{M}}$	sq.in.		
9. Gases by volume: $A^* = \frac{SCFM\sqrt{ZTM}}{6.32CKP}$ (SCFM @ 14.7 psia and 60°F)	sq.in.		

10. Relief valve size required: .017 [illegible] Selected: ______

*If ASME Code applies, divide A by 0.90.

INSTRUMENT WORK SHEET NO. 9.1

RELIEF VALVE CALCULATION
GAS OR VAPOR

(See Engineering Procedure No. 20)

CONTRACT NO.: 7729
ITEM NO.: [illegible] Sht 1 of 1
FLOW SHEET NO.: [illegible]
MADE BY: [illegible] DATE: 4-27-77
CHECKED BY: [illegible] DATE: [illegible]

BASIS OF SIZING: Critical Velocity , FIRE EXPOSURE TO JACKET FULL OF WATER.

ASSUMED. $S = f\left(\frac{L}{D}\right)$ BE SMALLEST RATHER THAN MAXIMUM S, I. MAJOR

GENERAL

Vessel Item Number & Description: 36-18 PLANETARY MIXER, MAX. CAPACITY = 250 G/L
Vessel Dimensions: Dia.: 3 Ft. Straight Shell: [illegible] Ft.
Design Pressure: JACKET 150 psig Design Temperature: 16[illegible] °F.
Insulation: ____ Volume: 33.4 Cu. Ft.

PROPERTIES OF CONTENTS

Fluid WATER CK = ____ d_v = ____ #/cu.ft. E = 0 BTU/Hr.
h = ____ BTU/Hr/Sq.Ft. K_{sh} = ____ L_v = 876 BTU/# M = ____
p = 165 psig P_1 = [illegible] psia T = ____ °R V = 0 gpm
Z = ____

L_v = HEAT OF VAPORIZATION OF WATER AT [illegible] PSIA = 876 BTU/lbm

CALCULATIONS

1. Wetted surface (Horizontal) $S = \pi D(.4D + .67L)$ = ____ sq. ft.
   (Vertical) $S = \pi D(.25D + L)$ = ____ sq. ft.
   $S = \pi D L$ = [illegible]

		Fire Conditions P_1 = 1.2 x Design Press.	Heater Duty P_1 = 1.1 x Design Press.
2. Heat input rate = H	BTU/hr.	0.3 x [illegible]	
3. Total heat input rate $Q = H + E$	BTU/hr.	[illegible]	
4. Vapor generation rate $W_1 = Q/L_v$	#/hr.	161	
5. Vapor displacement rate $W_2 = 8.02VD_v$	#/hr.	0	
6. Total discharge rate $W = W_1 + W_2$	#/hr.	161	
7. Steam: $A^* = \frac{W}{50P_1K_{sh}}$	sq.in.	.016	
8. Other Vapors: $A^* = \frac{W}{CKP_1}\sqrt{\frac{ZT}{M}}$	sq.in.		
9. Gases by volume: $A^* = \frac{SCFM\sqrt{ZTM}}{6.32CKP}$ (SCFM @ 14.7 psia and 60°F)	sq.in.		

10. Relief valve size required: .016 in² Selected: ____

*If ASME Code applies, divide A by 0.90.

SUBJECT

MADE BY ___ DATE ___

CHECKED BY ___ DATE ___

APPROVED BY ___ DATE ___

APPROVED BY ___ DATE ___

CONTRACT NO.

FLOW SHEET NO.

AREA NO.

ITEM NO.

DRAWING NO.

628-R1

PAGE 1 OF 2

CALCULATION

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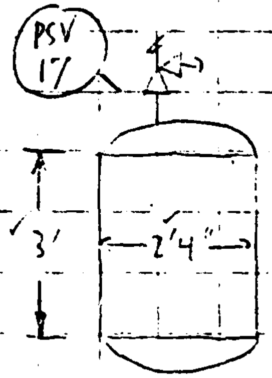


75219

REACTION WASTE RECEIVER

BASIS : FIRE EXPOSURE

DESIGN CONDITIONS : FV & 30 PSIG

SET PRESSURE OF PSV-17 = 30 PSIG

FLOWING PRESSURE = 1.2 × 30 + 14.3 = 50.

S = WETTED SURFACE AREA = $\frac{\pi D^2}{4} \times 1.66 + \pi D H$ = 29 ft^2

Q = RATE OF HEAT ABSORPTION = 0.3 × 21,000 (S)$^{0.82}$ = 99,657 BTU/HR

L = HEAT OF VAPORIZATION ≅ 100 BTU/lbm (L OF R-3 @ 50.0 PSIA)

W = DISCHARGE CAPACITY OF PSV-17 = $\frac{Q}{L}$ = 997 lbm/HR

A = ORIFICE AREA = $\frac{W\sqrt{T}\sqrt{Z}}{C_1 P_1 \sqrt{M}}$

* ASSUME VESSEL FULL OF R-3 M = 146.3

@ P_1 = 50.0 , T = 150°F + 460° = 610°R

Z = 0.85 , C_1 = 315

A = $\frac{997 \sqrt{610}\sqrt{0.85}}{\ldots}$ = 0.1 ... ⇒ USE "E" ORIFICE

INSTRUMENT WORK SHEET NO. 9.1

RELIEF VALVE CALCULATION
GAS OR VAPOR

(See Engineering Procedure No. 20)

CONTRACT NO.: [illegible]
ITEM NO.: [illegible]
FLOW SHEET NO.: [illegible]
MADE BY: [illegible] DATE: [illegible]
CHECKED BY: ______ DATE: ______

BASIS OF SIZING: Critical Velocity, FIRE EXPOSURE

Sheet 2 of 2

GENERAL

Vessel Item Number & Description: [illegible]
Vessel Dimensions: Dia.: 7.33 Ft. Straight Shell: [illegible] Ft.
Design Pressure: [illegible] psig Design Temperature: ______ °F.
Insulation: NONE Volume: ______ Cu. Ft.

PROPERTIES OF CONTENTS

WORST CASE: ASSUME FULL

Fluid [illegible] CK = [illegible] d_v = ______ #/cu.ft. E = 0 BTU/Hr.
h = ______ BTU/Hr/Sq.Ft. K_{sh} = ______ L_v = 100 BTU/# M = [illegible]
p = 30 psig P_1 = 50 psia T = [illegible] °R V = ______ gpm
Z = USE 1.0

CALCULATIONS

1. Wetted surface (Horizontal) $S = \pi D(.4D + .67L)$ = ______ sq. ft.
   (Vertical) $S = \pi D(.25D + L)$ = [illegible] sq. ft.

			Fire Conditions P_1 = 1.2 x Design Press.	Heater Duty P_1 = 1.1 x Design Press.
2.	Heat input rate = H	BTU/hr.	[illegible]	[illegible]
3.	Total heat input rate $Q = H + E$	BTU/hr.	[illegible]	
4.	Vapor generation rate $W_1 = Q/L_v$	#/hr.	[illegible]	
5.	Vapor displacement rate $W_2 = 8.02VD_v$	#/hr.	[illegible]	
6.	Total discharge rate $W = W_1 + W_2$	#/hr.	[illegible]	
7.	Steam: $A^* = \frac{W}{50P_1K_{sh}}$	sq.in.		
8.	Other Vapors: $A^* = \frac{W}{CKP_1}\sqrt{\frac{ZT}{M}}$	sq.in.	0.1[illegible]	
9.	Gases by volume: $A^* = \frac{SCFM\sqrt{ZTM}}{6.32CKP}$ (SCFM @ 14.7 psia and 60°F)	sq.in.		

10. Relief valve size required: E, 0.196 in² [illegible] Selected: ______

*If ASME Code applies, divide A by 0.90.

SUBJECT ______

MADE BY ______ DATE ______

CHECKED BY ______ DATE ______

APPROVED BY ______ DATE ______

APPROVED BY ______ DATE ______

CONTRACT NO. ______

FLOW SHEET NO. ______

AREA NO. ______

ITEM NO. ______

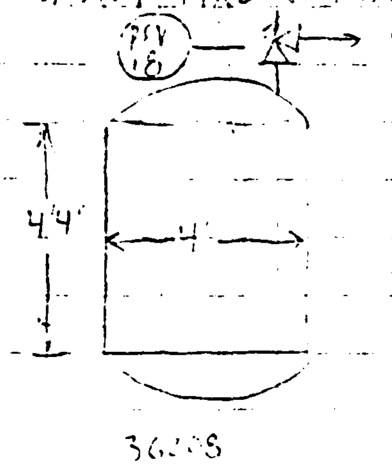
DRAWING NO. ______

PAGE 1 OF 3

CALCULATION

DRAVO CORPORATION • CHEMICAL PLANTS DIV. • PITTSBURGH, PA.

BASIS: FIRE EXPOSURE



DESIGN CONDITIONS:

[illegible]

PSV-18 SET PRESSURE = 15 psig

P_1 = FLOWING PRESSURE [illegible] = 32.3 psia

S = WETTED SURFACE AREA = $\frac{1.66\pi D^2}{4}$ [illegible] = 75.3 ft²

Q = RATE OF HEAT ABSORPTION = $0.3 \times 21{,}000\,(S)^{0.82}$ = 217,2[illegible].7 BTU/hr

VESSEL CONTENTS: PENTANE [illegible] (MW = 72.15)

L = HEAT OF VAPORIZATION = 144 BTU/lb [illegible]

W = DISCHARGE CAPACITY OF PSV-18 = $\frac{Q}{L}$ [illegible]

A = ORIFICE AREA = $\frac{W\sqrt{T}\sqrt{Z}}{C_1 P_1 \sqrt{M}}$

PENTANE — MW = 72.15, P_1 = 32.3, T = [illegible], Z = [illegible]

SUBJECT

MADE BY DATE
CHECKED BY DATE
APPROVED BY DATE
APPROVED BY DATE

CONTRACT NO. 3730
FLOW SHEET NO.
AREA NO.
ITEM NO. FV-10
DRAWING NO.

CALCULATION

$$A = \frac{1513\sqrt{605(0.72)}}{310(32.3)\sqrt{72.15}} = 0.412 \text{ in}^2$$

use "G" ORIFICE $1\frac{1}{2} \times 2\frac{1}{2}$

AREA = 0.503 in^2

INSTRUMENT WORK SHEET NO. 9.1

RELIEF VALVE CALCULATION
GAS OR VAPOR

(See Engineering Procedure No. 20)

CONTRACT NO.: [illegible]
ITEM NO.: [illegible]
FLOW SHEET NO.: [illegible]
MADE BY: [illegible] DATE: [illegible]
CHECKED BY: ______ DATE: ______

BASIS OF SIZING: Critical Velocity, FIRE EXPOSURE

Sheet 3 of 3

GENERAL

Vessel Item Number & Description: [illegible]
Vessel Dimensions: Dia.: [illegible] Ft. Straight Shell: [illegible] Ft.
Design Pressure: [illegible] psig Design Temperature: [illegible] °F.
Insulation: [illegible] Volume: ______ Cu. Ft.

PROPERTIES OF CONTENTS

Fluid [illegible] CK = [illegible] d_v = ______ #/cu.ft. E = [illegible] BTU/Hr.
h = ______ BTU/Hr/Sq.Ft. K_{sh} = ______ L_v = [illegible] BTU/# M = [illegible]
p = [illegible] psig P_1 = [illegible] psia T = [illegible] °R V = [illegible] gpm
Z = [illegible]

CALCULATIONS

1. Wetted surface (Horizontal) $S = \pi D(.4D + .67L)$ = ______ sq. ft.
   (Vertical) $S = \pi D(.25D + L)$ = [illegible] sq. ft.

	Fire Conditions P_1 = 1.2 x Design Press.	Heater Duty P_1 = 1.1 x Design Press.
2. Heat input rate = H — BTU/hr.	[illegible]	
3. Total heat input rate $Q = H + E$ — BTU/hr.	[illegible]	
4. Vapor generation rate $W_1 = Q/L_v$ — #/hr.	[illegible]	
5. Vapor displacement rate $W_2 = 8.02VD_v$ — #/hr.	[illegible]	
6. Total discharge rate $W = W_1 + W_2$ — #/hr.	[illegible]	
7. Steam: $A^* = \frac{W}{50P_1K_{sh}}$ — sq.in.		
8. Other Vapors: $A^* = \frac{W}{CKP_1}\sqrt{\frac{ZT}{M}}$ — sq.in.	[illegible]	
9. Gases by volume: $A^* = \frac{SCFM\sqrt{ZTM}}{6.32CKP}$ (SCFM @ 14.7 psia and 60°F) — sq.in.		

10. Relief valve size required: [illegible] Selected: ______

*If ASME Code applies, divide A by 0.90.

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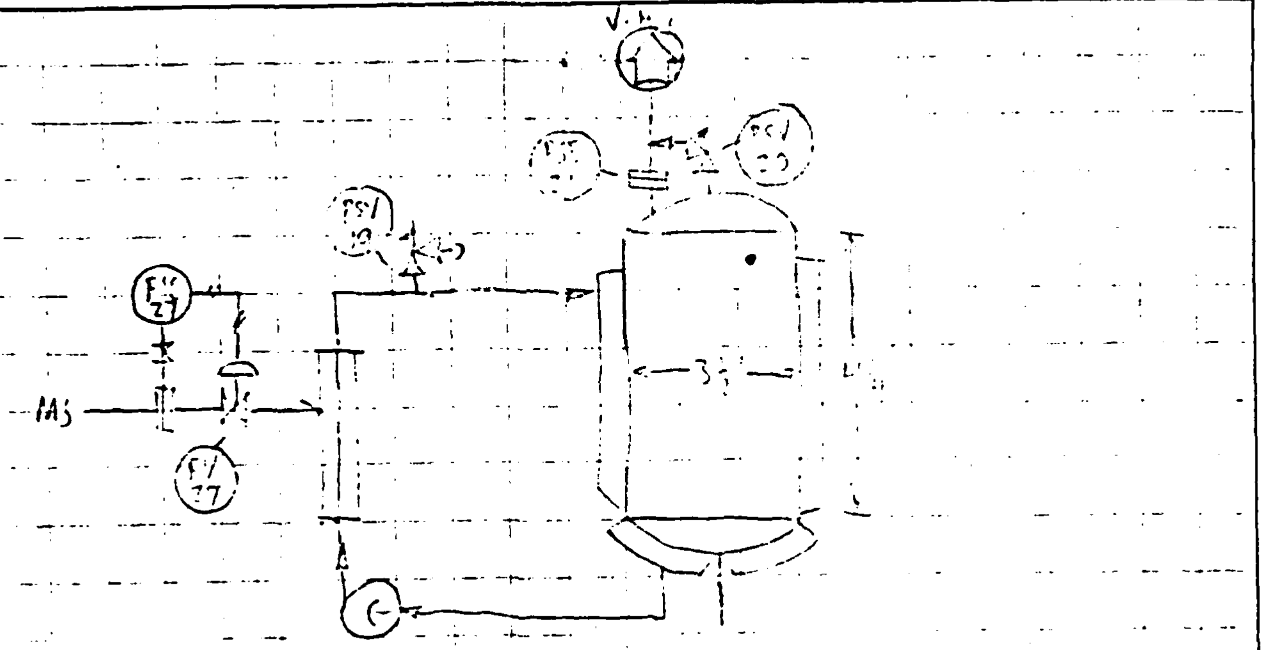
CALCULATION

SUBJECT	[illegible]	CONTRACT NO.	[illegible]
		FLOW SHEET NO.	
		AREA NO.	[illegible]
MADE BY	R[illegible]	DATE	[illegible]
CHECKED BY	[illegible]	DATE	[illegible]-29-77
APPROVED BY		DATE	
APPROVED BY		DATE	
		ITEM NO.	[illegible]
		DRAWING NO.	



35227
NPC [illegible] KETTLE

35227 – DESIGN CONDITIONS
VESSEL: 15 PSIG ✓
JACKET: 150 PSIG

ASSUME MAX. CAPACITY OF [illegible] = [illegible]

I FIND – MAXIMUM HEAT TRANSFER FROM STEAM TO VESSEL CONTENTS [illegible]:
1) ENTHALPY OF 150 PSIG [illegible] STEAM – ENTHALPY OF S[illegible] [illegible]

$1190 - 250 \frac{BTU}{lbm} = 940 \frac{BTU}{lbm}$

2) $Q = 940 \frac{BTU}{[illegible]} \times 200 \frac{lb}{hr} = 188{,}000 \frac{BTU}{hr}$

SUBJECT
CONTRACT NO.
FLOW SHEET NO.
AREA NO.
ITEM NO. PSU-19, PSU-20, PSU-21
MADE BY DATE
CHECKED BY DATE
DRAWING NO.
APPROVED BY DATE
APPROVED BY DATE
PAGE OF 3

CALCULATION

I. FIND HEAT TRANSFER TO VESSEL CONTENTS DUE TO FIRE EXPOSURE:

1) S = SURFACE AREA EXPOSED TO FIRE = ... = 627 ft^2

2) $Q = 0.3 \times 21{,}000 (S)^{0.82} = 187543$ BTU/HR

$\boxed{\text{USE } Q = 188{,}000 \text{ BTU/HR FOR SAFETY DEVICE SIZING.}}$

II. PSV-19 SIZING BASIS: FIRE EXPOSURE TO JACKET FULL OF WATER.

SET PRESSURE = 150 PSIG

P_1 = RELIEVING PRESSURE = 1.2 × 150 + 14.7 = 194.7 PSIA

L = HEAT OF VAPORIZATION OF 195 PSIA WATER = 845.6 BTU/LB

W = PSV-19 CAPACITY = $\frac{Q}{L} = \frac{188{,}000}{845.6}$ = 222 LB/HR

A = ORIFICE AREA = $\frac{W}{50 P_1}$ = .025 in^2

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SUBJECT

MADE BY ______ DATE ______
CHECKED BY ______ DATE ______
APPROVED BY ______ DATE ______
APPROVED BY ______ DATE ______

CONTRACT NO. ______
FLOW SHEET NO. ______
AREA NO. ______
ITEM NO. PSV-19, PSV-20, PSU-21
DRAWING NO. ______

PAGE ______ OF 3

CALCULATION

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IV. PSE-21 SIZING SET PRESSURE = 15 PSIG

BASIS: FIRE EXPOSURE

$Q = 188,000 \frac{BTU}{hr}$

$P_1 = 15 \times 1.2 + 14.7 = 32.7$ PSIA

L = HEAT OF VAPORIZATION OF HEPTANE AT 32.7 PSIA, 145°F = 144 $\frac{BTU}{lbm}$

W = PSE-21 CAPACITY = $\frac{Q}{L}$ = 1305 $\frac{lbm}{hr}$

RUPTURE DISC SIZING FORMULA:

$$d = \sqrt{\frac{W}{770}\sqrt{\frac{V_1}{P_1}}}$$

Assume ideal gas:

$$V_1 = R\frac{T_1}{P_1} = \frac{1545}{72.15} \frac{ft\cdot lbf}{lbm\cdot °R} \dots 605°R \dots = 2.73 \frac{ft^3}{lbm}$$

$$d = \sqrt{\frac{1305}{770}\sqrt{\frac{2.8}{32.7}}} = 0.7 \text{ in}$$ USE 1" DISC

USE 1½ WHERE 15#

V. PSV-20 USE "D" ORIFICE 1"X 2" — use 2x1½ to avoid ... pipe ... PSE

SUBJECT

MADE BY ____ DATE ____

CHECKED BY ____ DATE ____

APPROVED BY ____ DATE ____

APPROVED BY ____ DATE ____

CONTRACT NO. 7739

FLOW SHEET NO.

AREA NO.

ITEM NO.

DRAWING NO.

628-R1

CALCULATION

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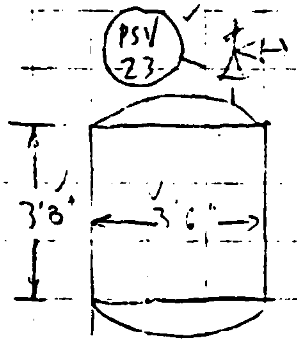
BASIS: FIRE EXPOSURE



DESIGN CONDITIONS: SV 25 PSIG

FLOWING PRESSURE = 25×1.2 + 14.3 = 44.3 PSIA

35239

PENTANE RECEIVER

S = WETTED SURFACE AREA = $\frac{1.66\pi D^2}{4} + \pi D H$ = 56.3 ft²

Q = RATE OF HEAT ABSORPTION = $0.3 \times 21{,}000\,(S)^{0.82}$ = 171,695 $\frac{BTU}{hr}$

L = HEAT OF VAPORIZATION = 140 $\frac{BTU}{lbm}$ @ 44.3 PSIA and 160°F

W = PSV-23 DISCHARGE CAPACITY = $\frac{Q}{L}$ = 1226 $\frac{lbm}{hr}$

A = ORIFICE AREA = $\frac{W\sqrt{TZ_1}}{C_1 P_1 \sqrt{M}}$ = 0.257 in²

FOR PENTANE P_1 = 44.3, T = 160°F = 620°R, Z = 0.95, M = 72.15
C_1 = 310

USE "F" ORIFICE (AREA = 0.307 in²).

INSTRUMENT WORK SHEET NO. 9.1

RELIEF VALVE CALCULATION
GAS OR VAPOR

(See Engineering Procedure No. 20)

CONTRACT NO.: [illegible]
ITEM NO.: [illegible]
FLOW SHEET NO.: [illegible]
MADE BY: [illegible] DATE: [illegible]
CHECKED BY: ______ DATE: ______

BASIS OF SIZING: Critical Velocity, FIRE EXPOSURE Sheet 2 of 2

GENERAL

Vessel Item Number & Description: 75739 [illegible]
Vessel Dimensions: Dia.: [illegible] Ft. Straight Shell: [illegible] Ft.
Design Pressure: [illegible] psig Design Temperature: ______ °F.
Insulation: [illegible] Volume: ______ Cu. Ft.

PROPERTIES OF CONTENTS

Fluid PENTANE CK = [illegible] d_v = ______ #/cu.ft. E = 0 BTU/Hr.
h = ______ BTU/Hr/Sq.Ft. K_{sh} = ______ L_v = [illegible] BTU/# M = [illegible]
p = [illegible] psig P_1 = [illegible] psia T = [illegible] °R V = 0 gpm
Z = USE 1.0

CALCULATIONS

1. Wetted surface (Horizontal) $S = \pi D(.4D + .67L)$ = ______ sq. ft.
   (Vertical) $S = \pi D(.25D + L)$ = [illegible] sq. ft.

		Fire Conditions P_1 = 1.2 x Design Press.	Heater Duty P_1 = 1.1 x Design Press.
2. Heat input rate = H	BTU/hr.	WATER SPRAY [illegible]	
3. Total heat input rate $Q = H + E$	BTU/hr.	157,[illegible]	
4. Vapor generation rate $W_1 = Q/L_v$	#/hr.	[illegible]	
5. Vapor displacement rate $W_2 = 8.02VD_v$	#/hr.	0	
6. Total discharge rate $W - W_1 + W_2$	#/hr.	[illegible]	
7. Steam: $A^* = \frac{W}{50P_1K_{sh}}$	sq.in.		
8. Other Vapors: $A^* = \frac{W}{CKP_1}\sqrt{\frac{ZT}{M}}$	sq.in.	[illegible]	[illegible]
9. Gases by volume: $A^* = \frac{SCFM\sqrt{ZTM}}{6.32CKP}$ (SCFM @ 14.7 psia and 60°F)	sq.in.		

10. Relief valve size required: F [illegible] Selected: ______

*If ASME Code applies, divide A by 0.90.

SUBJECT

CONTRACT NO.
FLOW SHEET NO.
AREA NO.
ITEM NO. PSV-26
DRAWING NO.

MADE BY ____ DATE ____
CHECKED BY ____ DATE ____
APPROVED BY ____ DATE ____
APPROVED BY ____ DATE ____

PAGE 1 OF 1

CALCULATION

PSV-26 SIZING ; REFERENCE - PSV-25 [illegible]TION

SET AT 15 PSIG

FIRE EXPOSURE TO JACKET FULL OF TRAPPED WA[illegible]

Q = 92,490 BTU/HR (REF. PG. 1 OF CALCULATION [illegible]

L = HEAT OF VAPORIZATION [illegible] 41 [illegible]

$W = \frac{Q}{L} = 93$ [illegible]

A = ORIFICE AREA = [illegible] [illegible]

USE D ORIFICE, AREA = 0.110 in² [illegible] ¼ x 1 [illegible]

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INSTRUMENT WORK SHEET NO. 9.1

RELIEF VALVE CALCULATION
GAS OR VAPOR

CONTRACT NO.: [illegible]
ITEM NO.: [illegible] Sheet 1 of 1
FLOW SHEET NO.: [illegible]
MADE BY: [illegible] DATE: [illegible]
CHECKED BY: [illegible] DATE: [illegible]

(See Engineering Procedure No. 20)

BASIS OF SIZING: Critical Velocity, FIRE EXPOSURE [illegible] (PER L. CASPER 4-28-77).

GENERAL

Vessel Item Number & Description: [illegible]
*Vessel Dimensions: Dia.: [illegible] Ft. Straight Shell: [illegible] Ft.
Design Pressure: ______ psig Design Temperature: ______ °F.
Insulation: ______ Volume: ______ Cu. Ft.

PROPERTIES OF CONTENTS

WORST CASE:

Fluid [illegible] CK = [illegible] d_v = ______ #/cu.ft. E = ______ BTU/Hr.
h = ______ BTU/Hr/Sq.Ft. K_{sh} = ______ L_v = [illegible] BTU/# M = [illegible]
p = [illegible] psig P_1 = [illegible] psia T = [illegible] °R V = [illegible] gpm
Z = ______

*VESSEL DIMENSIONS PER L. COOPER 4-28-77

CALCULATIONS

1. Wetted surface (Horizontal) $S = \pi D(.4D + .67L)$ = ______ sq. ft.
   (Vertical) $S = \pi D(.25D + L)$ = [illegible] sq. ft.

		Fire Conditions P_1 = 1.2 x Design Press.	Heater Duty P_1 = 1.1 x Design Press.
2. Heat input rate = H	BTU/hr.	[illegible]	
3. Total heat input rate $Q = H + E$	BTU/hr.	[illegible]	
4. Vapor generation rate $W_1 = Q/L_v$	#/hr.	[illegible]	
5. Vapor displacement rate $W_2 = 8.02VD_v$	#/hr.		
6. Total discharge rate $W = W_1 + W_2$	#/hr.	[illegible]	
7. Steam: $A^* = \frac{W}{50P_1K_{sh}}$	sq.in.		
8. Other Vapors: $A^* = \frac{W}{CKP_1}\sqrt{\frac{ZT}{M}}$	sq.in.	[illegible]	
9. Gases by volume: $A^* = \frac{SCFM\sqrt{ZTM}}{6.32CKP}$ (SCFM @ 14.7 psia and 60°F)	sq.in.		

10. Relief valve size required: [illegible] in² Selected: [illegible]

*If ASME Code applies, divide A by 0.90.

INSTRUMENT WORK SHEET NO. 9.1

RELIEF VALVE CALCULATION
GAS OR VAPOR

(See Engineering Procedure No. 20)

CONTRACT NO.: [illegible]
ITEM NO.: [illegible] Sheet 1 of 1
FLOW SHEET NO.: [illegible]
MADE BY: [illegible] DATE: [illegible]
CHECKED BY: [illegible] DATE: [illegible]

BASIS OF SIZING: Critical Velocity, FIRE EXPOSURE
FILTER ELEMENT [illegible] (per Lee Cooke 4-23-77)

GENERAL

Vessel Item Number & Description: [illegible]
* Vessel Dimensions: Dia.: [illegible] Ft. Straight Shell: ________ Ft.
Design Pressure: [illegible] psig Design Temperature: ________ °F.
Insulation: ________ Volume: ________ Cu. Ft.

* PER L. COOKEY 4-23-77

PROPERTIES OF CONTENTS

Fluid [illegible] CK = [illegible] d_v = ________ #/cu.ft. E = ________ BTU/Hr.
h = ________ BTU/Hr/Sq.Ft. K_{sh} = ________ L_v = [illegible] BTU/# M = [illegible]
p = [illegible] psig P_1 = [illegible] psia T = [illegible] °R V = ________ gpm
Z = ________

CALCULATIONS

1. Wetted surface (Horizontal) $S = \pi D(.4D + .67L)$ = ________ sq. ft.
   (Vertical) $S = \pi D(.25D + L)$ = [illegible] sq. ft.

		Fire Conditions P_1 = 1.2 x Design Press.	Heater Duty P_1 = 1.1 x Design Press.
2. Heat input rate = H	BTU/hr.	[illegible]	
3. Total heat input rate $Q = H + E$	BTU/hr.	[illegible]	
4. Vapor generation rate $W_1 = Q/L_v$	#/hr.	[illegible]	
5. Vapor displacement rate $W_2 = 8.02VD_v$	#/hr.	0	
6. Total discharge rate $W = W_1 + W_2$	#/hr.	[illegible]	
7. Steam: $A^* = \frac{W}{50P_1K_{sh}}$	sq.in.		
8. Other Vapors: $A^* = \frac{W}{CKP_1}\sqrt{\frac{ZT}{M}}$	sq.in.	.0??	
9. Gases by volume: $A^* = \frac{SCFM\sqrt{ZTM}}{6.32CKP}$ (SCFM @ 14.7 psia and 60°F)	sq.in.		

10. Relief valve size required: .0419 [illegible] Selected: [illegible]
([illegible])

*If ASME Code applies, divide A by 0.90.

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CALCULATION

SUBJECT ______

MADE BY ______ DATE ______

CHECKED BY ______ DATE ______

APPROVED BY ______ DATE ______

APPROVED BY ______ DATE ______

CONTRACT NO. ______

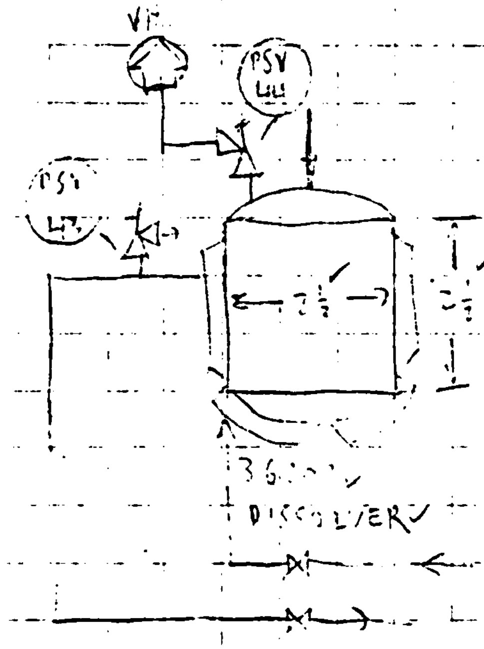
FLOW SHEET NO. ______

AREA NO. ______

ITEM NO. PSV [illegible]

DRAWING NO. ______

15 + 12 + 14.7 = 33.7



36207

DESIGN CONDITIONS

VESSEL 15 [illegible]

JACKET F/V 150 [illegible]

VESSEL CONTENTS R-11 (M = 130)

R-2 (M = [illegible])

[illegible] (M = [illegible])

*REFERENCE - PSV-56 CALCULATION

BASIS FOR SIZING PSV-44: [illegible] *

[illegible]

(LOWEST HEAT OF VAPORIZATION)

L = HEAT OF VAPORIZATION OF R-11 [illegible]

W = PSV-44 DISCHARGE CAPACITY = $\frac{Q}{L}$ = [illegible]

A = SURFACE AREA = $\frac{W}{C K P_1}\sqrt{\frac{TZ}{M}}$ = 0 [illegible]

DATA FOR R-11: P = 33.7 PSIA, T = [illegible], [illegible], Z = 1.0

SUBJECT

MADE BY ____ DATE ____
CHECKED BY ____ DATE ____
APPROVED BY ____ DATE ____
APPROVED BY ____ DATE ____

CONTRACT NO. 2739
FLOW SHEET NO.
AREA NO.
ITEM NO. PSV-43, PSV-44
DRAWING NO.

CALCULATION

BASIS FOR SIZING PSV-43: FIRE EXPOSURE TO JACKET [illegible] OF [illegible] WATER

C = WETTED AREA = $\frac{1.66\pi D^2}{4} + \pi D L$ = 27.7 FT² ✓

Q = 0.3 × [illegible] $(S)^{0.82}$ = 96,2[illegible] [illegible] ✓

L = HEAT OF VAPORIZATION OF [illegible] WATER = [illegible]845 $\frac{BTU}{Ton}$ ✓.

W = PSV-43 DISCHARGE CAPACITY = $\frac{Q}{L}$ = [illegible] ✓

A = $\frac{W}{50P_1}$ = .012 in² ✓ USE "D" [illegible] = 0.11[illegible] ([illegible])

[illegible] = 150 × 1.2 + 14.7 = [illegible]

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INSTRUMENT WORK SHEET NO. 9.1

RELIEF VALVE CALCULATION
GAS OR VAPOR

(See Engineering Procedure No. 20)

CONTRACT NO.: 2739
ITEM NO.: PSV-45
FLOW SHEET NO.: 113-700
MADE BY: RPT DATE: 4-15-77
CHECKED BY: [illegible] DATE: [illegible]

BASIS OF SIZING: Critical Velocity, FIRE EXPOSURE

GENERAL

Vessel Item Number & Description: 2620' METHANOL-ACETONE TANK
Vessel Dimensions: Dia.: [illegible] Ft. Straight Shell: [illegible] Ft
Design Pressure: [illegible] psig Design Temperature: [illegible]
Insulation: NONE Volume: ______ Cu. Ft.

PROPERTIES OF CONTENTS

Fluid METHANOL-ACETONE SOLUTION CK = 320 d_v = ______ #/cu.ft. E = 0 BTU/Hr
h = ______ BTU/Hr/Sq.Ft. K_{sh} = ______ L_v = [illegible] BTU/# M = 47
p = 15 psig P_1 = 32.3 psia T = [illegible] °R V = 0
Z = [illegible]

*for L_v and M values see previous calculation 1-4-77.

CALCULATIONS

1. Wetted surface (Horizontal) $S = \pi D(.4D + .67L)$ = ______ sq. ft.
(Vertical) $S = \pi D(.25D + L)$ = 53.6 sq. ft.

		Fire Conditions P_1 = 1.2 x Design Press.	Heater Duty P_1 = 1.1 x Design Press.
2. Heat input rate = H	BTU/hr.	[illegible]	
3. Total heat input rate $Q = H + E$	BTU/hr.	[illegible]	
4. Vapor generation rate $W_1 = Q/L_v$	#/hr.	517	
5. Vapor displacement rate $W_2 = 8.02VD_v$	#/hr.	0	
6. Total discharge rate $W = W_1 + W_2$	#/hr.	517	
7. Steam: $A^* = \frac{W}{50P_1K_{sh}}$	sq.in.		
8. Other Vapors: $A^* = \frac{W}{CKP_1}\sqrt{\frac{ZT}{M}}$	sq.in.	0.18	
9. Gases by volume: $A^* = \frac{SCFM\sqrt{ZTM}}{6.32CKP}$ (SCFM @ 14.7 psia and 60°F)	sq.in.		

10. Relief valve size required: E, 0.196 in² (1 X 2) Selected: ______

*If ASME Code applies, divide A by 0.90.

INSTRUMENT WORK SHEET NO. 9.1

RELIEF VALVE CALCULATION
GAS OR VAPOR

CONTRACT NO.: 2739
ITEM NO.: PV-48
FLOW SHEET NO.: 113-204
MADE BY: RPT DATE: 9-26-77
CHECKED BY: [illegible] DATE: [illegible]

(See Engineering Procedure No. 20)

BASIS OF SIZING: Critical Velocity, FIRE EXPOSURE

GENERAL

Vessel Item Number & Description: 35755 METHANOL-ACETONE CHARGING TANK
Vessel Dimensions: Dia.: 2 [illegible] Ft. Straight Shell: [illegible] Ft.
Design Pressure: 15 psig Design Temperature: [illegible] °F.
Insulation: ______ Volume: ______ Cu. Ft.

PROPERTIES OF CONTENTS

Fluid METHANOL-ACETONE [illegible] CK = [illegible] d_v = ____ #/cu.ft. E = 0 BTU/Hr.
h = ____ BTU/Hr/Sq.Ft. K_{sh} = ____ L_v = [illegible] BTU/# M = 47
p = 15 psig P_1 = [illegible] psia T = 146.6+460 °R V = 0 gpm
Z = [illegible]

* SEE PSV-45 CALCULATION FOR L_V AND M VALUES.

CALCULATIONS

1. Wetted surface (Horizontal) $S = \pi D(.4D + .67L)$ = ____ sq. ft.
   (Vertical) $S = \pi D(.25D + L)$ = [illegible] sq. ft.

		Fire Conditions P_1 = 1.2 x Design Press.	Heater Duty P_1 = 1.1 x Design Press.
2. Heat input rate = H	BTU/hr.	0.3 x 280,000	
3. Total heat input rate $Q = H + E$	BTU/hr.	34,000	
4. Vapor generation rate $W_1 = Q/L_v$	#/hr.	256	
5. Vapor displacement rate $W_2 = 8.02VD_v$	#/hr.	0	
6. Total discharge rate $W = W_1 + W_2$	#/hr.	256	
7. Steam: $A^* = \frac{W}{50P_1K_{sh}}$	sq.in.		
8. Other Vapors: $A^* = \frac{W}{CKP_1}\sqrt{\frac{ZT}{M}}$	sq.in.	.037	
9. Gases by volume: $A^* = \frac{SCFM\sqrt{ZTM}}{6.32CKP}$ (SCFM @ 14.7 psia and 60°F)	sq.in.		

10. Relief valve size required: D. 0.110 [illegible] 1 x 2 1 Selected: ______

*If ASME Code applies, divide A by 0.90.

SUBJECT ___
FILTER WASH TANK

MADE BY P.P.T DATE 2-17-77
CHECKED BY ___ DATE 2-17-77
APPROVED BY ___ DATE ___
APPROVED BY ___ DATE ___

CONTRACT NO. ___
FLOW SHEET NO. 172-204
AREA NO. ___
ITEM NO. 75253 / PSV-50
DRAWING NO. ___

PAGE 1 OF ___

DRAVO CORPORATION • CHEMICAL PLANTS DIV. • PITTSBURGH, PA.

CALCULATION

BASIS: FIRE EXPOSURE

VOID
CCW JACKETED VESSEL

P_1 = FLOWING PRESSURE = 32.3

$L = 4'$

$D = 2'$

$$A = 0.75\left[2(1.66)\frac{\pi D^2}{4} + \pi D L\right] = 26.7\ FT^2$$

$$Q = 21{,}000\,(A)^{0.82} = 310{,}160\ \text{BTU/HR}$$

METHANOL-ACETONE

λ = LATENT HEAT OF VAPORIZATION = 326.6 BTU/LB @ 146°F
(SEE PSV SIZING FOR VESSEL 76201)

$$W = \frac{Q}{\lambda} = 950\ \text{LB/HR}$$

PSV SIZING

$$A = \frac{W}{C_1 P_1}\sqrt{\frac{T Z_1}{(MW)}}$$

$W = 950$

$P_1 = 32.3$

$T = 146°F + 460 = 606$

$MW = 46.85$

$Z_1 = 0.95$

$C_1 = 318$

$A = 0.324\ in^2$

G ORIFICE AREA = 0.503 in^2

USE $1\frac{1}{2}'' \times 2\frac{1}{2}''$ G ORIFICE 150# R.F.

G ORIFICE WILL PASS ~ 60 GPM @ 15 PSI SET PRESSURE

INSTRUMENT WORK SHEET NO. 9.1

RELIEF VALVE CALCULATION
GAS OR VAPOR

(See Engineering Procedure No. 20)

BASIS OF SIZING: Critical Velocity , FIRE

CONTRACT NO.: 2739
ITEM NO.: [illegible]
FLOW SHEET NO.: [illegible]
MADE BY: [illegible] DATE: [illegible]
CHECKED BY: [illegible] DATE: [illegible]

GENERAL

Vessel Item Number & Description: [illegible]
Vessel Dimensions: Dia.: [illegible] Ft. Straight Shell: [illegible] Ft.
Design Pressure: 15 psig Design Temperature: [illegible] °F.
Insulation: ______ Volume: ______ Cu. Ft.

PROPERTIES OF CONTENTS

Fluid [illegible] CK = [illegible] d_v = ______ #/cu.ft. E = 0 BTU/Hr.
h = ______ BTU/Hr/Sq.Ft. K_{sh} = ______ L_v = [illegible] BTU/# M = [illegible]
p = 15 psig P_1 = [illegible] psia T = 665 °R V = 0 gpm
Z = [illegible]

CALCULATIONS

1. Wetted surface (Horizontal) $S = \pi D(.4D + .67L)$ = ______ sq. ft.
   (Vertical) $S = \pi D(.25D + L)$ = [illegible] sq. ft.

		Fire Conditions P_1 = 1.2 x Design Press.	Heater Duty P_1 = 1.1 x Design Press.
2. Heat input rate = H	BTU/hr.	[illegible]	[illegible]
3. Total heat input rate $Q = H + E$	BTU/hr.	[illegible]	
4. Vapor generation rate $W_1 = Q/L_v$	#/hr.	[illegible]	
5. Vapor displacement rate $W_2 = 8.02VD_v$	#/hr.	[illegible]	
6. Total discharge rate $W - W_1 + W_2$	#/hr.	[illegible]	
7. Steam: $A^* = \frac{W}{50P_1K_{sh}}$	sq.in.		
8. Other Vapors: $A^* = \frac{W}{CKP_1}\sqrt{\frac{ZT}{M}}$	sq.in.	[illegible]	
9. Gases by volume: $A^* = \frac{SCFM\sqrt{ZTM}}{6.32CKP}$ (SCFM @ 14.7 psia and 60°F)	sq.in.		

10. Relief valve size required: [illegible] Selected: ______

*If ASME Code applies, divide A by 0.90.

INSTRUMENT WORK SHEET NO. 9.1

RELIEF VALVE CALCULATION	CONTRACT NO.: ________
GAS OR VAPOR	ITEM NO.: ________
	FLOW SHEET NO.: ________
(See Engineering Procedure No. 20)	MADE BY: ________ DATE: ________
	CHECKED BY: ________ DATE: ________

BASIS OF SIZING: Critical Velocity

GENERAL

Vessel Item Number & Description: ________

Vessel Dimensions: Dia.: ________ Ft. Straight Shell: ________ Ft.

Design Pressure: ________ psig Design Temperature: ________ °F.

Insulation: ________ Volume: ________ Cu. Ft.

PROPERTIES OF CONTENTS

Fluid ________ CK = ________ d_v = ________ #/cu.ft. E = ________ BTU/Hr.

h = ________ BTU/Hr/Sq.Ft. K_{sh} = ________ L_v = ________ BTU/# M = ________

p = ________ psig P_1 = ________ psia T = ________ °R V = ________ gpm

Z = ________

CALCULATIONS

1. Wetted surface (Horizontal) $S = \pi D(.4D + .67L)$ = ________ sq. ft.
   (Vertical) $S = \pi D(.25D + L)$ = ________ sq. ft.

		Fire Conditions P_1 = 1.2 x Design Press.	Heater Duty P_1 = 1.1 x Design Press.
2. Heat input rate = H	BTU/hr.		
3. Total heat input rate $Q = H + E$	BTU/hr.		
4. Vapor generation rate $W_1 = Q/L_v$	#/hr.		
5. Vapor displacement rate $W_2 = 8.02VD_v$	#/hr.		
6. Total discharge rate $W = W_1 + W_2$	#/hr.		
7. Steam: $A^* = \frac{W}{50P_1K_{sh}}$	sq.in.		
8. Other Vapors: $A^* = \frac{W}{CKP_1}\sqrt{\frac{ZT}{M}}$	sq.in.		
9. Gases by volume: $A^* = \frac{SCFM\sqrt{ZTM}}{6.32CKP}$ (SCFM @ 14.7 psia and 60°F)	sq.in.		

10. Relief valve size required: ________ Selected: ________

*If ASME Code applies, divide A by 0.90.

SUBJECT

MADE BY [illegible] DATE [illegible]
CHECKED BY [illegible] DATE [illegible]
APPROVED BY [illegible] DATE [illegible]
APPROVED BY DATE

CONTRACT NO.
FLOW SHEET NO.
AREA NO.
ITEM NO.
DRAWING NO.

PAGE 1 OF

CALCULATION

PSV-53 SIZING ; REF. PSV-56 CALCULATION

36204 JACKET DESIGN CONDITIONS : [illegible] 15 PSIG @ 250°F ✓
SET PSV-53 @ 15 PSIG ✓
FLOWING PRESSURE AT RELIEF : [illegible] ✓

FV-[illegible] FULL OPEN, [illegible] WATER [illegible]
IN JACKET.
([illegible] SEE [illegible] CALCULATION FOR PSV-56) ✓

L = [illegible] VAPORIZATION OF [illegible] ✓

[illegible] = 159 lb/hr ✓

A = ORIFICE AREA = W / (5 C P₁) = [illegible] ✓

"E" ORIFICE AREA = [illegible] ✓

SUBJECT ______

CONTRACT NO. ______
FLOW SHEET NO. ______
AREA NO. ______
ITEM NO. ______
DRAWING NO. ______

MADE BY ______ DATE ______
CHECKED BY ______ DATE ______
APPROVED BY ______ DATE ______
APPROVED BY ______ DATE ______

CALCULATION

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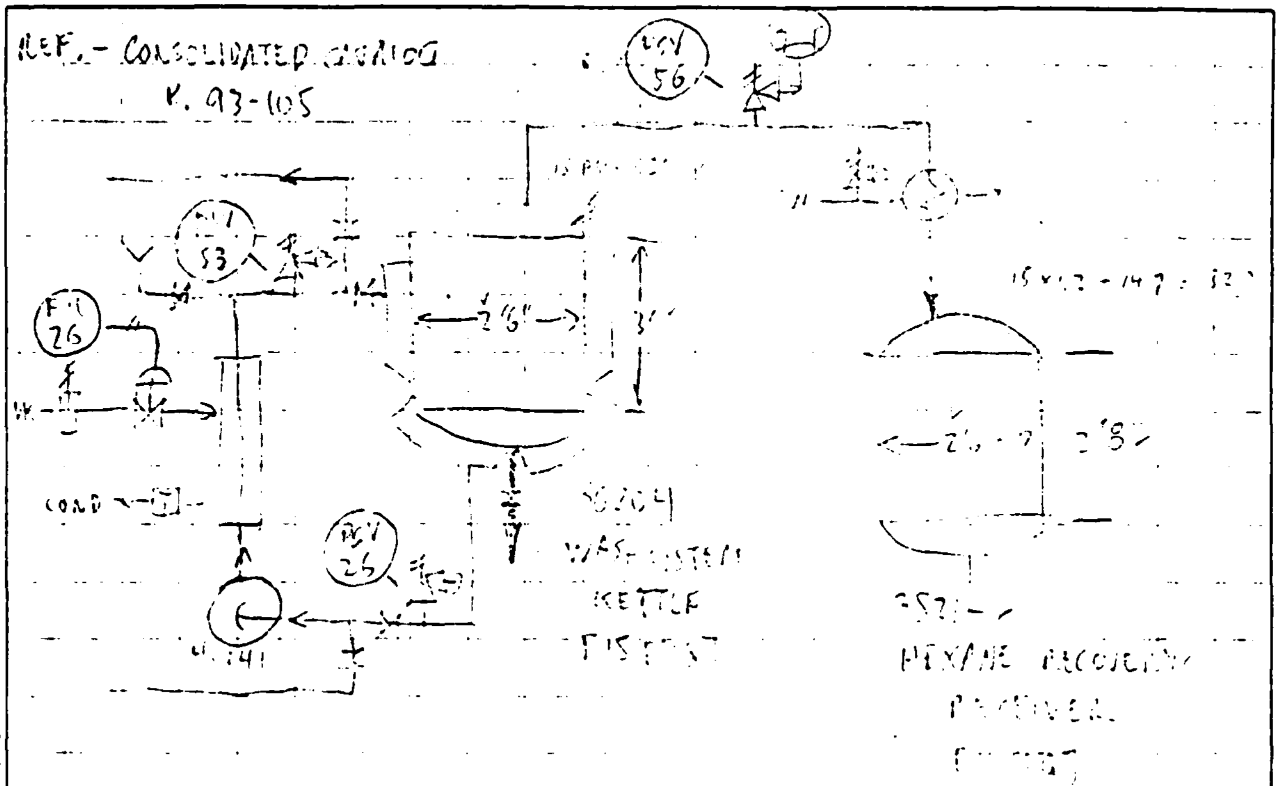
REF. - CONSOLIDATED [illegible]
P. 93-105



DETERMINE WORST CONDITION FOR RELIEF OF [illegible]

CASE I: FIRE EXPOSURE TO [illegible]

[illegible]

[illegible]

L = 13.5 [illegible]

W = $\frac{Q}{L}$ = [illegible]

SUBJECT	CONTRACT NO. 2751
	FLOW SHEET NO.
	AREA NO.
MADE BY / DATE	ITEM NO. PSV-56
CHECKED BY / DATE	DRAWING NO.
APPROVED BY / DATE	
APPROVED BY / DATE	PAGE 2 OF 3

CALCULATION

CASE II: FIRE EXPOSURE TO [illegible]204 FULL OF HEXANE, HEAT TRANSFERRED FROM WATER TO JACKET TO HEXANE.

$S = \frac{[illegible]\pi D^2}{4} + \pi DH = [illegible] ft^2$

$Q = 0.[illegible] \times [illegible],000 [S]^{0.82} = [illegible] \frac{BTU}{hr}$

$L = 135 \frac{BTU}{lbm}$ HEXANE @ [illegible] PSI and [illegible]°F.

$\therefore \frac{Q}{L} = 704 \frac{lbm}{hr}$

CASE III: FV-26 FULL OPEN, [illegible]204 FULL OF HEXANE. [illegible] WILL BE TRANSFERRED TO [illegible]204.

FV-26 [illegible] CAPACITY [illegible] $\frac{lb}{hr}$

ASSUME STEAM TRAP WILL PASS FLOW,

ENTHALPY OF [illegible] STEAM − ENTHALPY OF [illegible] CONDENSATE = [illegible] − [illegible] BTU/lbm = [illegible] BTU/lbm

$Q = 2[illegible] \frac{lbm}{hr} \times [illegible] \frac{BTU}{lbm} = [illegible] \frac{BTU}{hr}$

DRAVO CORPORATION • CHEMICAL PLANTS, DIV. • PITTSBURGH, PA.

SUBJECT ____________________

MADE BY ________ DATE ________
CHECKED BY ________ DATE ________
APPROVED BY ________ DATE ________
APPROVED BY ________ DATE ________

CONTRACT NO. ________
FLOW SHEET NO. ________
AREA NO. ________
ITEM NO. PSU-56
DRAWING NO. ________

DRAVO CORPORATION • CHEMICAL PLANTS, DIV. • PITTSBURGH, PA.

CALCULATION

$L = 135 \frac{BTU}{lbm}$ HEXANE @ [illegible]

$W = \frac{Q}{L} = \frac{188,000}{135} = 1393 \frac{lbm}{hr}$

WORST CASE II: $W = 1393 \frac{lbm}{hr}$

$A = \frac{W}{C K_d P_1} \sqrt{\frac{TZ}{M}} = 0.33 \text{ in}^2$

DATA FOR HEXANE: C_1 = [illegible] $T = 560$ [illegible]
$M = 86$ [illegible]

USE "G" ORIFICE 0.503 [illegible]

INSTRUMENT WORK SHEET NO. 9.1

RELIEF VALVE CALCULATION
GAS OR VAPOR

(See Engineering Procedure No. 20)

CONTRACT NO.: ______
ITEM NO.: ______
FLOW SHEET NO.: ______
MADE BY: ______ DATE: ______
CHECKED BY: ______ DATE: ______

BASIS OF SIZING: Critical Velocity, BLOCKED OUTLET

GENERAL

Vessel Item Number & Description: ______
Vessel Dimensions: Dia.: ______ Ft. Straight Shell: ______ Ft.
Design Pressure: ______ psig Design Temperature: ______ °F.
Insulation: ______ Volume: ______ Cu. Ft.

PROPERTIES OF CONTENTS

Fluid ______ CK = ______ d_v = ______ #/cu.ft. E = ______ BTU/Hr.
h = ______ BTU/Hr/Sq.Ft. K_{sh} = ______ L_v = ______ BTU/# M = ______
p = ______ psig P_1 = ______ psia T = ______ °R V = ______ gpm
Z = 1.0

CALCULATIONS

1. Wetted surface (Horizontal) $S = \pi D(.4D + .67L)$ = ______ sq. ft.
   (Vertical) $S = \pi D(.25D + L)$ = ______ sq. ft.

		Fire Conditions $P_1 = 1.2 \times$ Design Press.	~~Heater Duty~~ $P_1 = 1.1 \times$ Design Press.
2. Heat input rate = H	BTU/hr.		
3. Total heat input rate $Q = H + E$	BTU/hr.		
4. Vapor generation rate $W_1 = Q/L_v$	#/hr.		
5. Vapor displacement rate $W_2 = 8.02VD_v$	#/hr.		
6. Total discharge rate $W = W_1 + W_2$	#/hr.		
7. Steam: $A^* = \dfrac{W}{50P_1K_{sh}}$	sq.in.		
8. Other Vapors: $A^* = \dfrac{W}{CKP_1}\sqrt{\dfrac{ZT}{M}}$	sq.in.		
9. Gases by volume: $A^* = \dfrac{SCFM\sqrt{ZTM}}{6.32CKP}$ (SCFM @ 14.7 psia and 60°F)	sq.in.		

10. Relief valve size required: ______ Selected: ______

*If ASME Code applies, divide A by 0.90.

APPENDIX E

DESIGN DOCUMENT LIST

DESIGN DOCUMENT LIST

Document	Rev	Title	Type
103-201	2	B10 Production	PFD
104-201	2	NHC Production	PFD
104-202	2	NHC Purification	PFD
105-201	2	Utilities	PFD
106-201	2	Waste Disposal	PFD
110-201	3	Legend	EFD
111-201	3	Raw Material Storage	EFD
111-202	3	Raw Material Storage Drums	EFD
113-201	3	First Stage B10 Production	EFD
113-202	3	Second Stage B10 Production	EFD
113-203	3	Third Stage B10 Production	EFD
113-204	3	B10 Filtration	EFD
113-205	3	B10 Wash Recovery	EFD
114-201	3	NHC Production	EFD
114-202	3	NHC Wash System	EFD
114-203	3	Pentane Distillation	EFD
114-204	3	NHC Purification	EFD
115-201	3	Steam	EFD
115-202	3	Cooling Water, Chilled Water	EFD
115-203	3	Air Nitrogen	EFD
116-201	3	Process Drain	EFD
116-202	3	Incineration	EFD
117-201	0	Off Sites	EFD

DESIGN DOCUMENT LIST (cont.)

Document	Rev	Title	Type
125-201	3	Water and Steam Balance	UFD
125-202	3	Cooling Water Balance	UFD
125-203	3	Air and Nitrogen	UFD
200-000		Voided Site Work and Studies	
200-101	2	Plot Plan	DWG
211-101	1	TKFarm Layout Plan & Section	DWG
211-102	1	TKFarm Layout Plan & Section	DWG
212-101	1	DrumSTG Layout Plan & Section	DWG
216-101	0	Servrack Layout Plan & Section	DWG
216-201	0	Servrack Layout Section	DWG
230-101	1	B10 Area Layout Plan - Reactors	DWG
230-102	1	B10 Area Layout Plan - Filtration and Recovery	DWG
230-103	1	B10 Area Layout Plan - Roof	DWG
230-104	1	B10 Area Layout - Roof Plan	DWG
230-201	1	B10 Area Layout Section	DWG
230-202	1	B10 Area Layout Section	DWG
240-101	1	NHC Area Layout Plan - 1st Floor	DWG
240-102	1	NHC Area Layout Plan - 2nd Floor	DWG
240-103	1	NHC Area Layout Plan - Roof	DWG
240-201	1	NHC Area Layout Section	DWG
240-202	1	NHC Area Layout Section	DWG
240-203	1	NHC Area Layout Section	DWG
250-101	1	Utility Layout Plan	DWG
250-201	1	Utility Layout Section	DWG
251-101	0	CoolTWR Layout Plan and Section	DWG

DESIGN DOCUMENT LIST (cont.)

Document	Rev	Title	Type
260-101	0	Incinr Layout Plan	DWG
260-201		Incinr Layout Section	DWG
260-202		Incinr Layout Section	DWG
M1	1	General Spec for Mech Equip.	SPEC
EC-B		B10 Area	CALC
EC-D		Drum Storage	CALC
EC-H		Change House	CALC
EC-N		NHC Area	CALC
EC-U		Boiler House	CALC
H-1	0	HVac Basic	SPEC
H-15	A	Mechanical S/C	SPEC
H-15.5		Env Control S/C	SPEC
400-001	A	Cover Sheet	DWG
400-002	A	Systems Diagram	DWG
400-003	A	Systems Diagram	DWG
412-001	A	Drunstg Plan and Sections	DWG
415-001	A	Changers Plan, Section and Details	DWG
430-001	A	B10 Area Plan and Sections	DWG
430-002	A	B10 Area Plan and Sections	DWG
430-003	A	B10 Area Plan and Sections	DWG
440-001	A	NHC Area Plan, Sections and Floors	DWG
440-002	A	NHC Area Plan and Sections - Roof	DWG
440-003	A	NHC Area Sections and Details	DWG
440-004	A	NHC Area Sections	DWG

DESIGN DOCUMENT LIST (cont.)

Document	Rev	Title	Type
450-001	A	Utility Plan, Section and Details	DWG
C-01	0	Instr Design Basis	SPEC
C-04	A	Prefabricated Instrument Panels	SPEC
C-10	0	Hazard Spec	SPEC
CAL-01		Relief Headers	CALC
600-001	0	IP 1 to 7	PARGMT
600-002	0	IP 8 and 9	PARGMT
600-003	0	IP-1 thru IP-9 Arrgmt and Fabr	PARGMT
600-004	A	Intrinsic Safety Barrier Cabinet	PARGMT
610-001		Installation Details	IDTL
610-002		Installation Details	IDTL
610-003		Installation Details	IDTL
610-004		Installation Details	IDTL
610-005		Installation Details	IDTL
610-006		Installation Details	IDTL
610-007		Installation Details	IDTL
610-008		Installation Details	IDTL
610-009		Installation Details	IDTL
610-010		Installation Details	IDTL
610-099	1	Electrical Instr Connections	IDTL
620-001	0	Legend and Notes	ICD
621-001	0	Raw Material Storage	ICD
621-002	0	Raw Material Storage Drums	ICD
623-001	0	B10 Production	ICD

DESIGN DOCUMENT LIST (cont.)

Document	Rev	Title	Type
623-002	0	Product Filter	ICD
624-001	0	NHC Production	ICD
625-001	0	Utilities Area	ICD
626-001		Waste Disposal	ICD
650-001	A	Sheet 1	PTD
650-002	A	Sheet 2	PTD
650-003	A	Sheet 3	PTD
650-004	A	Sheet 4	PTD
650-005	A	Sheet 5	PTD
690-001	A	IP-1 thru IP-7	PWD
690-002	A	IP-1 thru IP-7	PWD
M730-001		B10 Area Model (Process)	MODEL
M730-002		B10 Area Model Reactor Area	
M740-001		NHC Area Model	MODEL
170-000		Boided Routing Dwgs	
170-201		Steam and Cond	DWG
170-202		City Water and Fire Water	DWG
170-203		Process Water	DWG
170-204		Chilled Water	DWG
170-205		Cooling Water	DWG
170-206		Instrument Air and Breathing Air	DWG
170-207		Nitrogen	DWG
170-208		Wash Vent	DWG
170-209		NHC Vent and High Velocity Vent	DWG

DESIGN DOCUMENT LIST (cont.)

Document Rev	Title	Type
170-210	B10 Vent	DWG
700-001	Misc Piping and General Notes	DWG
710-101	Yard Piping Plan and Sect	DWG
711-101	TKFarm Piping Plan	DWG
711-141	TKFarm Piping Sect	DWG
712-101	Drumstg Piping Plan and Sect	DWG
715-181	ChangeHS Plumbing Plan	DWG
715-182	ChangeHS Plumbing Sects	DWG
716-101	ServRack Piping Plan and Sects	DWG
716-102	ServRack Piping Plan and Sects	DWG
716-103	ServRack Piping Plan and Sects	DWG
716-104	ServRack Piping Plan and Sects	DWG
716-105	ServRack Piping Plan and Sects	DWG
730-101	B10 Area Pipe Racks - Piping Plan	DWG
730-102	B10 Area Piping - Service Rack Sects and Dtls	DWG
730-201	B10 Area ISO's (180)	ISOS
740-101	NHC Area Pipe Racks - Piping Plan	DWG
740-201	NHC Area ISO's (180)	ISOS
750-101	Utility Piping Plan	DWG
750-141	Utility Piping Sect	DWG
750-142	Utility Piping Sect	DWG
751-101	CoolTWR Piping Plan	DWG
760-101	Incinr Piping Plan	DWG

DESIGN DOCUMENT LIST (cont.)

Document	Rev	Title	Type
760-102		Incinr Piping Plan	DWG
760-141		Incinr Piping Sect	DWG
760-142		Incinr Piping Sect	DWG
760-143		Incinr Incinerator	DWG
J-1		Insulation Spec	SPEC
P-1	A	Piping Materials	SPEC
P-2	A	Piping Fabrication	SPEC
Q-1	0	Plumbing Spec	SPEC
BS-G1	0	Basic Specification	SPEC
G01.001		Introduction and Scope of Project	CONTR DOC
G01.002		Instructions to Bidders	CONTR DOC
G01.003		General Conditions	CONTR DOC
G01.005		Bid Form	CONTR DOC
R04.101		Concrete Masonry	SPEC
R05.201	A	Metal Roof Decking	SPEC
R07.102	A	Area Ins - Min Board Steel Deck	SPEC
R07.106	A	Bldg Insul SR Fgs US Mtl Conc FM	SPEC
R07.204	1	Laminated Membrane Roofing	SPEC
R07.205	A	Penetration Membrane Roofing	SPEC
R07.306	A	Prefin Stl Siding and Roofing	SPEC
R07.401	A	Sheet Metal Flashing	SPEC
R07.501	0	Elastic Flashing - Neoprene	SPEC
R07.601	0	Gutters and Downspouts	SPEC
R07.701	0	Caulking and Sealants	SPEC
R08.101	A	Hollow Mtl Doors and Frames Core RE	SPEC

DESIGN DOCUMENT LIST (cont.)

Document	Rev	Title	Type
R08.301	0	Overhead Doors	SPEC
R08.501		Finish Hardware	SPEC
R08.502	0	Lock Cylinders	SPEC
R08.601	A	Aluminum Windows - Projected	SPEC
R08.701	0	Glass and Glazing	SPEC
R08.801	0	Weatherstripping	SPEC
R09.101	0	Vinyl ASB Tile Flooring	SPEC
R09.103	0	Ceramic Tile Floors - Dry Set	SPEC
R09.202	0	Prefin Hdbd Dry Wall System	SPEC
R09.603	B	Lay-In Acoustical Tile Ceiling	SPEC
R09.701		Painting - Materials and Workmanship	SPEC
R09.704		Painting - General Painting	SPEC
R09.801		Fireproofing Mastic	SPEC
R09.900	0	Equipment Surface Prep and Priming	SPEC
R10.102	0	Mtl Toilet Part - Flush FL MTL BRC	SPEC
R10.201	0	Lockers and Benches	SPEC
R10.202	A	Toilet Room Accessories	SPEC
R10.203	0	Metal Shower Enclosure	SPEC
R13.202	A	Pre-Fab Building Frame	SPEC
SC-1		Special Conditions	CONTR DOC
S03.101	0	Cast-In-Place Concrete	SPEC
S05.101	A	Structural Metal	SPEC
S05.102	0	Miscellaneous Metal	SPEC
T02.202	A	Clearing and Grubbing	SPEC

DESIGN DOCUMENT LIST (cont.)

Document	Rev	Title	Type
T02.301	A	Rough Grading	SPEC
T02.303	A	Fills and Embankments	SPEC
T02.304	A	Excav Fill and Bkfill Str	SPEC
T02.305	A	Excav Bedng and Bkfill Sewers	SPEC
T02.501	A	Prep of Subgrade	SPEC
T02.503		Dense Grd Aggr Base Course	SPEC
T02.504		Bitum Prime Coat	SPEC
T02.506		Dense Grd Hot Laid Plant Mix	SPEC
T02.507		Bitum Surface Course	SPEC
T02.701		Finish Grading	SPEC
T02.705	A	Steel Chain Link Fence	SPEC
800-101		Project Door Schedule	DWG
800-102		Project Room Fin Sched and Clg Plans	DWG
800-105		Guardhouse Plans and Elevations	DWG
800-106		Guardhouse Sections and Details	DWG
810-101		Yard Pump House Plan and Sections	DWG
812-101	A	Drumstg Floor Plan and Roof Area	DWG
812-131	A	Drumstg Elevations	DWG
815-101		Changehs Floor Plan and Roof Plan	DWG
815-131		Changehs Area Elevations	DWG
815-132		Changehs Sections and Details	DWG
830-101		B10 Area Floor Plan and Roof Plan	DWG
830-131		B10 Area Elevations	DWG
830-132		B10 Area Sections and Details	DWG

DESIGN DOCUMENT LIST (cont.)

Document	Rev	Title	Type
830-133		B10 Area Detail Office Plan	DWG
830-134		B10 Area Stair Plans, Sections and Details	DWG
830-135		B10 Area Sects and Detls	DWG
840-101		NHC Area Floor Plan and Roof Plan	DWG
840-131		NHC Area Elevations	DWG
840-132		NHC Area Sections and Details	DWG
840-133		NHC Area Sections and Details SH2	DWG
840-134		NHC Area Stair Plans and Sections	DWG
840-135		NHC Area Stair Details	DWG
850-101	A	Utility Floor Plan and Roof Plan	DWG
850-131	A	Utility Area Elevations	DWG
850-132	A	Utility Sections and Details	DWG
C800-221		Sewer	CALC
C800-271		Roads and Paving	CALC
C800-281		Grading	CALC
C811-241		TKFarm Fdns	CALC
C812-601		Drumstg Fdn and Grade Slab	CALC
C815-601		Changehs Foundation	CALC
C816-501		ServRack Pipe Rack Steel	CALC
C816-901		ServRack Pipe Rack Fdn	CALC
C830-301		B10 Area Roof Framing	CALC
C830-302		NHC Area Roof Framing	CALC
C830-401		B10 Area Misc Steel	CALC

DESIGN DOCUMENT LIST (cont.)

Document	Rev	Title	Type
C830-402		B10 Area Superstructure	CALC
C830-601		B10 Area Superstructure Fdn	CALC
C830-701		B10 Area Grade and Slab Fdn	CALC
C830-801		B10 Area Roof Slab	CALC
C840-301		NHC Area Superstructure	CALC
C840-401		NHC Area Platform Steel	CALC
C840-601		NHC Area Superstructure Fdn	CALC
C840-701		NHC Area Grade Slab and Fdn	CALC
C850-601		Utility Superstructure Fdn	CALC
C850-701		Utility Grade Slab and Fdn	CALC
C851-601		CoolTwr Design Fdn	CALC
C860-601		Incinr Superstructure Fdns	CALC
C860-701		Incinr Equip Fdn and Slab	CALC
800-000		Voided Site Work and Studies	DWG
800-215		Fence - Plan and Sections	DWG
800-216		Plan of Facilities - Block Plan #1	DWG
800-217		Plan of Facilities - Block Plan #2	DWG
800-223		Process Sewers - Plan	DWG
800-224		Process Sewers - Sect	DWG
800-225		Sanitary Sewers - Plan	DWG
800-226		Sanitary Sewers - Sect	DWG
800-227		Sanitary Sewer to Existing Plant	DWG
800-228		Quench Wtr Line to Exst Plnt-Pln	DWG

DESIGN DOCUMENT LIST (cont.)

Document	Rev	Title	Type
800-229		Quench Wtr Line to Exst Plnt-Sct	DWG
800-230		B2 & NG Line to Exist Plant-Plan	DWG
800-231		B2 & NG Line to Exist Plant-Sect	DWG
800-274		Roads and Paving Plan	DWG
800-275		Roads and Paving Sections	DWG
800-276		Access Road to Main Highway-Plan	DWG
800-277		Access Road to Main Highway-Sect	DWG
800-284		Rough Grading Plan	DWG
800-285		Rough Grading Plan	DWG
800-286		Rough Grading Sections	DWG
800-287		Finish Grading	DWG
800-951	1	Handrail - Stairs - Grating	DWG
800-952	0	Ladders and Cages	DWG
800-953	0	General Notes and Misc Dtls	DWG
800-954	0	Concrete Dtls	DWG
810-251		Yard Details Sht #1	DWG
810-252		Yard Details Sht #2	DWG
811-243		TKFarm Plan	DWG
811-244		TKFarm Sections	DWG
812-602		Drumstg Foundation Plan	DWG
813-227		Electss Plan and Sect	DWG
815-601		ChangeHS Foundation Plan	DWG
816-501		ServRack Plan	DWG
816-531		Servrack Sects and Dtls #1	DWG
816-532		ServRack Sects and Dtls #2	DWG
816-902		ServRack Fdns - Plan	DWG

DESIGN DOCUMENT LIST (cont.)

Document	Rev	Title	Type
816-931		ServRack Fdns - Sects and Dtls	DWG
830-301		B10 Area Roof Plan	DWG
830-302		B10 Area Second Floor Plan	DWG
830-331		B10 Area Elevations Sht #1	DWG
830-332		B10 Area Elevations Sht #2	DWG
830-401		B10 Area Misc Platforms and Walkways	DWG
830-402		B10 Area Stairs Plan and Sections	DWG
830-403		B10 Area Misc Platforms and Walkways	DWG
830-602		B10 Area Foundation Plan	DWG
830-631		B10 Area Fdns Sects and Dtls	DWG
830-701		B10 Area Grade Slab and Equip Fdns Plan	DWG
830-731		B10 Area Grade Slab and Sects and Dtls	DWG
830-801		B10 Area Roof Slab	DWG
840-301		NHC Area Roof Plan	DWG
840-302		NHC Area Second Floor Plan	DWG
840-331		NHC Area Elevations Sht #1	DWG
840-332		NHC Area Elevations Sht #2	DWG
840-401		NHC Area Misc Platforms and Walkways	DWG
840-402		NHC Area Misc Platforms and Walkways	DWG
840-602		NHC Area Foundation Plan	DWG
840-631		NHC Area Fdns - Sects and Dtls	DWG
840-701		NHC Area Grade Slab and Equip Fdns Pln and Scts	DWG

DESIGN DOCUMENT LIST (cont.)

Document	Rev	Title	Type
840-801		NHC Area Roof Slab	DWG
850-602		Utility Foundation Plan	DWG
850-631		Utility Fdns - Sects and Dtls	DWG
850-701		Utility Grade Slab and Equip Fdns	DWG
850-731		Utility Grade Slab - Sects and Dtls	DWG
851-601		CoolTWR Foundation Plan	DWG
860-601		Incinr Foundation Plan	DWG
860-631		Incinr Fdns Sects and Dtls	DWG
860-701		Incinr Grade Slab Plan	DWG
860-731		Incinr Grade Slab - Sects and Dtls	DWG
E-1	0	Elect Basic Spec	SPEC
E-2	A	Installation Specs	SPEC
ES-14-1	3	Power Standard Details	SPEC
ES-24-1	3	Lighting Standard Details	SPEC
ES-41-1	4	Grounding Standard Details	SPEC
900-SKE001		Load Study	DWG
900-SKE002		Heat Tracing and Pole Line	CALC
900-101	A	General Notes and Equip List	DWG
900-103	0	480V Unit Sub-Sta Specs Sheet	DWG
900-104	0	480V Unit Data Sheet	DWG
900-105	A	MCC Spec Sheet	DWG
900-106	A	Lighting Panel and Fixture Sch	DWG
900-107		Lighting Panel Schedules	DWG

DESIGN DOCUMENT LIST (cont.)

Document	Rev	Title	Type
900-111	1	Master One Line Diag	DWG
900-201		8320V Dist Plan	DWG
900-202		8320V Dist Plan	DWG
900-203		8320V Pole Line Details	DWG
900-204		8320V Pole Line Details	DWG
900-205		Electric Heat Tracing	DWG
900-206		Electric Heat Tracing	DWG
900-207		Electric Heat Tracing	DWG
900-208		Electric Heat Tracing	DWG
900-209		Heat Tracing Pnl Schedule	DWG
900-210		Heat Tracing Pnl Schedule	DWG
900-301	A	Instrument One Line Diagrams	DWG
900-302		Instrument One Line Diagrams	DWG
900-303		Pkg Unit Connect Dia	DWG
900-304	A	B10 Area Relay Panel Conn Diag	DWG
900-305	A	B10 Area Interconnection Diag	DWG
910-201	A	Yard Distr Plot Plan	DWG
911-201	A	TKFarm Power Contl Ltg Grd Plans	DWG
912-201	A	Drumstg Pwr, Cont. Ltg and Grd	DWG
913-201		Electss Substation Layout	DWG
915-201		ChangeHS Pwr. Contl. Ltg and Grd Plans	DWG
930-111	0	B10 Area MCC Single Line Diagram	DWG
930-112	0	B10 Area MCC Single Line Diagram	DWG
930-131	A	B10 Area MCC Arrgt & Data Sheet	DWG

DESIGN DOCUMENT LIST (cont.)

Document	Rev	Title	Type
930-151	A	B10 Area Elementary Diagrams	DWG
930-201	A	B10 Area Power and Control - 1st Fl	DWG
930-202	A	B10 Area Power and Control - 1st Fl	DWG
930-203	A	B10 Area Power and Control - 2nd Fl	DWG
930-204	A	B10 Area Power and Control - 2nd Fl	DWG
930-205	A	B10 Area Pwr, Cont, Ltg & Grd - Roof Plan	DWG
930-401	A	B10 Area Ltg and Grd 1st Fl	DWG
930-402	A	B10 Area Ltg and Grd 1st Fl	DWG
930-403	A	B10 Area Ltg and Grd 2nd Fl	DWG
930-404	A	B10 Area Ltg and Grd 2nd Fl	DWG
940-111	0	NHC Area MCC Single Line Diagram	DWG
940-112	0	NHC Area MCC Single Line Diagram	DWG
940-131	A	NHC Area MCC Arrgt and Data Sheet	DWG
940-151	A	NHC Area Elementary Diagrams	DWG
940-152	A	NHC Area Elementary Diagrams	DWG
940-201	A	NHC Area Power and Control 1st Fl	DWG
940-202	A	NHC Area Power and Control 1st Fl	DWG
940-203	A	NHC Area Roof - Pwr, Cont Ltg and Grd	DWG
940-401	A	NHC Area 1st Fl Ltg and Grd	DWG
940-402	A	NHC Area 2nd Fl Ltg and Ground	DWG
950-111	0	Utility MCC Single Line Diagram	DWG
950-112	0	Utility MCC Single Line Diagram	DWG
950-131	A	Utility MCC Arrgt and Data Sheet	DWG
950-151		Utility Elementary Diagrams	DWG

DESIGN DOCUMENT LIST (cont.)

Document	Rev	Title	Type
950-201		Utility Power and Control	DWG
950-401	A	Utility Ltg and Grd Plan	DWG
960-201		Incinr Power and Control	DWG
960-401		Incinr Ltg and Ground Plans	DWG

ADDENDUM 1

INTRODUCTION AND SUMMARY

This addendum to the final technical report (Data Item A001) previously submitted under contract DAAK40-76-C-1256 presents supplemental information pertinent to the design of the NHC production facility. At the time of the previous submission, major design revisions were being made to the incineration waste disposal system and thus the submission of the final waste disposal system design package was deferred. This final incinerator/waste disposal system design package was transmitted under separate cover in September, 1978 and forms a part of this first report addendum.

Other pertinent design information contained in this addendum includes a description of project management responsibility, the design bibliography, a listing of design package contents and descriptions of appendices to be submitted as later report addenda.

PROJECT MANAGEMENT RESPONSIBILITY

Callery Chemical Company

As prime contractor for the NHC production facility design, Callery Chemical Company will maintain a master project file. Contents of this master file will be maintained for the life of the NHC facility and will be available for retrieval by the U. S. Army Missile R & D Command or their designated representatives. Master file contents will include original tracings, copies of all other design documentation and vendor data for each item of major purchased equipment.

Callery personnel responsible for project management and design file maintenance are as follows:

Robert A. Brown, Program Manager
William J. Cooper, Assistant Program Manager
Louis M. Rossi, Contract Administrator

The mailing address for the above Callery personnel is

Callery Chemical Company
Division of Mine Safety Appliances Company
Callery, Pennsylvania 16024

Dravo Corporation

Chemical Plants Division of Dravo Corporation was the design engineering subcontractor for the NHC facility and as such will maintain a complete design file for a minimum of five years from completion of the design. Contents of the Dravo design file will include copies of all drawings and originals of all other design documents and design calculations.

Dravo design responsibility and design file maintenance is under the cognizance of the following individual:

Charles A. Huber
Project Manager, NHC Production Facility
Chemical Plants Division
Dravo Corporation
One Oliver Plaza
Pittsburgh, Pennsylvania 15222

DESIGN BIBLIOGRAPHY

Appendix A of this addendum lists those reports, documents and references employed in the design of the NHC facility. Included in Appendix A are project reports, general design documents and references and process development references.

DESIGN PACKAGE CONTENTS

Appendix B of this addendum provides a current listing of the contents of the design package.

LATER APPENDICES

Supplemental addenda to the final technical report on NHC facility design will be prepared and submitted at later dates. These later appendices will constitute the Standard Operating Procedures (SOP) package and will include:

1. Emergency Procedures
2. Safety Manual
3. Analytical Procedures
4. Maintenance Procedures (including lay away)
5. Operating Procedures (including startup, normal operation and shutdown/lay away)

The initial SOP package will be prepared and submitted for review prior to operator training and startup of the NHC facility. The SOP package will be utilized for training, checkout, startup, and demonstration. As procedures are refined, the SOP package will be updated and modified to reflect actual operating experience.

Appendices C and D of this addendum illustrate the format of the SOP package. Appendix C illustrates the initial operating procedures as developed for the pentane distillation system. Appendix D illustrates the initial maintenance procedures with a specific example of the NHC hot water pump, equipment item 41248.

APPENDIX A

DESIGN BIBLIOGRAPHY

DESIGN BIBLIOGRAPHY

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Inspection System Program Plan, Data Sequence No A00G, Contract DAAK40-76-C-1256, February 22, 1977

Quality Control Plan NHC Production Facility, Contract DAAK40-76-C-1256, September 30, 1977

Environmental Aspects Report, Data Sequence No. A00E, Contract DAAK40-76-C-1256, May 18, 1977

Technical Report on Facility Design, Data Sequence No's. A005 and A006, Contract DAAK40-76-C-1256, May 11, 1977

Reliability, Availability, Maintainability Analysis Report, Data Sequence No. A00F, Contract DAAK40-76-C-1256, October 31, 1977

GENERAL DESIGN DOCUMENTS AND REFERENCES

Occupational Safety and Health Standards,
Code of Federal Regulations,
Title 29, Chapter XVII

DOD Contractors' Manual for Ammunition,
Explosives and Related Materials,
DOD 4145.26M

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DOD 4270.1-M

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APPENDIX B

DESIGN DOCUMENT LIST

Dravo

Chemical Plants Division

Project
Management
Report

Document Status

DOCUMENT STATUS

This report shows the status of engineering documents for the project. In addition to status information, it indicates target and current completion dates, highlighting late documents and special conditions or problems. IN refers to the date the item went in its current status and OUT is the date the item is expected to go out of this status, that is the operation will be complete. The report is organized by department and may be limited by the user to specific departments of interest. It is intended to provide a very detailed look at the status of engineering.

STATUS SYMBOLS

KEYWORD	MEANING	KEYWORD	MEANING
LIST	*Identify Item - Known to be Needed*	**CONSTR**	*Issued for Construction*
PREP	*Document being Prepared, Drawn, Typed, etc.*	**DONE**	*Document completed and Construction Issue not required*
CHK	*Document being Checked*	**HOLD**	*Being held - See Remark*
APRV	*Document being Approved*	**DELETE**	*Has been Deleted - See Remark*
ISSUE	*Document being Revised for Issue*	**SPARE**	*To Reserve a Spare Number*

RESPONSIBILITY SYMBOLS

KEYWORD	MEANING	KEYWORD	MEANING
PROC	*Process*	**PIPNG**	*Piping*
INSTR	*Instruments*	**MTO**	*Pipe Spec/Materials*
VESSL	*Vessels*	**STRES**	*Pipe Stress Analysis*
MECH	*Mechanical Equipment*	**ARCH**	*Architectural*
HVAC	*Heating, Ventilation & Air Conditioning*	**CIVIL**	*Civil*
MDES	*Mechanical Design*	**ELECT**	*Electrical*
LO	*Layout*	**PROJ**	*Project Staff*
MODEL	*Model Makers*	**CR**	*Central Records*
		CUST	*Customer*

CHEMI ·LANTS DIVISION

DOCUMENT STATUS SYSTEM
DOCUMENT STATUS SYSTEM
DOCUMENT STATUS SYSTEM

DSS STATUS REPORT
CPD-2739 CALLERY CHEMICAL COMPANY
NHC PLANT

*** PROCESS DEPARTMENT ***

DOCUMENT	REV	TITLE	TYPE	CLIENT NO	C/A SCHED COMPLETE	LASTREPT EXPECTED COMPLETE ISSUED	REMARK IN	STATUS	RESP	OUT	BY
103-201	3	B10 PRODUCTION	PFD		12-02-77	ISSUED ISSUED	01-11-78	CONSTR	PROC	ISSUED	OSBORNE
104-201	3	NHC PRODUCTION	PFD		12-02-77	ISSUED ISSUED	01-11-78	CONSTR	PROC	ISSUED	OSBORNE
104-202	3	NHC PURIFICATION	PFD		12-02-77	ISSUED ISSUED	01-11-78	CONSTR	PROC	ISSUED	OSBORNE
105-201	3	UTILITIES	PFD		12-02-77	ISSUED ISSUED	01-11-78	CONSTR	PROC	ISSUED	OSBORNE
106-201	3	WASTE DISPOSAL	PFD		12-02-77	ISSUED ISSUED	01-11-78	CONSTR	PROC	ISSUED	OSBORNE
110-201	6	LEGEND	EFD		04-25-77	ISSUED ISSUED	09-08-78	CONSTR	PROC	ISSUED	OSBORNE
111-201	8	RAW MATERIAL STORAGE	EFD		04-25-77	ISSUED ISSUED	01-09-79	CONSTR	PROC	ISSUED	OSBORNE
111-202	6	RAW MATERIAL STORAGE DRUMS	EFD		04-25-77	ISSUED ISSUED	08-01-78	CONSTR	PROC	ISSUED	OSBORNE
113-201	7	FIRST STAGE B10 PRODUCTION	EFD		04-25-77	ISSUED ISSUED	08-01-78	CONSTR	PROC	ISSUED	OSBORNE
113-202	7	SECOND STAGE B10 PRODUCTION	EFD		04-25-77	ISSUED ISSUED	08-01-78	CONSTR	PROC	ISSUED	OSBORNE
113-203	7	THIRD STAGE B10 PRODUCTION	EFD		04-25-77	ISSUED ISSUED	08-01-78	CONSTR	PROC	ISSUED	OSBORNE
113-204	9	B10 FILTRATION	EFD		04-25-77	ISSUED ISSUED	01-09-79	CONSTR	PROC	ISSUED	OSBORNE
113-205	9	B10 WASH RECOVERY	EFD		04-25-77	ISSUED ISSUED	01-24-79	CONSTR	PROC	ISSUED	OSBORNE
114-201	8	NHC PRODUCTION	EFD		04-25-77	ISSUED ISSUED	09-08-78	CONSTR	PROC	ISSUED	OSBORNE
114-202	9	NHC WASH SYSTEM	EFD		04-25-77	ISSUED ISSUED	01-24-79	CONSTR	PROC	ISSUED	OSBORNE
114-203	10	PENTANE DISTILLATION	EFD		04-25-77	ISSUED ISSUED	01-24-79	CONSTR	PROC	ISSUED	OSBORNE
114-204	10	NHC PURIFICATION	EFD		04-25-77	ISSUED	01-24-79	CONSTR	PROC	ISSUED	OSBORNE

CHEMI' .ANTS DIVISION

DOCUMENT STATUS SYSTEM
DOCUMENT STATUS SYSTEM
DOCUMENT STATUS SYSTEM

DSS STATUS REPORT
CPD-2739 CALLERY CHEMICAL COMPANY
NHC PLANT

*** PROCESS DEPARTMENT ***

DOCUMENT	REV	TITLE	TYPE	CLIENT NO	C/A SCHED COMPLETE	LASTREPT EXPECTED COMPLETE	REMARK IN	STATUS	RESP	OUT	BY
115-201	7	STEAM	EFD		04-25-77	ISSUED ISSUED	01-09-79	CONSTR	PROC	ISSUED	OSBORNE
115-202	8	COOLING WATER, CHILLED WATER	EFD		04-25-77	ISSUED ISSUED	01-09-79	CONSTR	PROC	ISSUED	OSBORNE
115-203	5	AIR NITROGEN	EFD		04-25-77	ISSUED ISSUED	01-12-78	CONSTR	PROC	ISSUED	OSBORNE
116-201	9	PROCESS DRAIN	EFD		04-25-77	ISSUED ISSUED	01-09-79	CONSTR	PROC	ISSUED	OSBORNE
116-202	8	INCINERATION	EFD		04-19-78	ISSUED ISSUED	01-09-79	CONSTR	PROC	ISSUED	OSBORNE
117-201	6	OFF SITES	EFD		A06-23-77 02-10-78	ISSUED ISSUED	01-09-79	CONSTR	PROC	ISSUED	OSBORNE
125-201	4	WATER AND STEAM BALANCE	UFD		12-02-77	ISSUED ISSUED	01-11-78	CONSTR	PROC	ISSUED	OSBORNE
125-202	3	COOLING WATER BALANCE	UFD		12-02-77	ISSUED ISSUED	06-17-77	CONSTR	PROC	ISSUED	LOHNES
125-203	4	AIR & NITROGEN	UFD		12-02-77	ISSUED ISSUED	01-11-78	CONSTR	PROC	ISSUED	OSBORNE

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*** LAYOUT DEPARTMENT ***

DOCUMENT	REV	TITLE	TYPE	CLIENT NO	C/A SCHED COMPLETE	LASTREPT EXPECTED COMPLETE	REMARK IN	STATUS	RESP	OUT	BY
200-101	7	PLOT PLAN	DWG		A06-07-77 05-13-77	ISSUED ISSUED	12-11-78	CONSTR	LO	ISSUED	OSBORNE
211-101	6	TKFARM LAYOUT PLAN & SECTION	DWG		A04-18-77 05-20-77	ISSUED ISSUED	09-13-78	CONSTR	LO	ISSUED	OSBORNE
211-102	6	TKFARM LAYOUT PLAN & SECTION	DWG		A04-18-77 05-20-77	ISSUED ISSUED	09-13-78	CONSTR	LO	ISSUED	OSBORNE
212-101	4	DRUMSTG LAYOUT PLAN & SECTION	DWG		A04-18-77 04-20-77	ISSUED ISSUED	12-19-78	CONSTR	LO	ISSUED	OSBORNE
216-101	4	SERVRACK LAYOUT PLAN & SECTION	DWG		A06-23-77	ISSUED ISSUED	03-27-78	CONSTR	LO	ISSUED	OSBORNE
216-201	2	SERVRACK LAYOUT SECTION	DWG		A06-23-77 06-17-77	ISSUED ISSUED	04-04-78	CONSTR	LO	ISSUED	OSBORNE
230-101	8	BIOAREA LAYOUT PLAN - REACTORS	DWG		A04-18-77 04-20-77	ISSUED ISSUED	12-21-78	CONSTR	LO	ISSUED	OSBORNE
230-102	7	BIOAREA LAYOUT PLAN - FILTRATION&RECOVRY	DWG		A04-18-77 04-20-77	ISSUED ISSUED	09-13-78	CONSTR	LO	ISSUED	OSBORNE
230-103	6	BIOAREA LAYOUT PLAN - ROOF	DWG		A04-18-77 04-20-77	ISSUED ISSUED	09-13-78	CONSTR	LO	ISSUED	OSBORNE
230-104	9	BIOAREA LAYOUT - ROOF PLAN	DWG		A04-18-77 04-20-77	ISSUED ISSUED	12-21-78	CONSTR	LO	ISSUED	OSBORNE
230-201	7	BIOAREA LAYOUT SECTION	DWG		A04-18-77 04-20-77	ISSUED ISSUED	09-13-78	CONSTR	LO	ISSUED	OSBORNE
230-202	6	BIOAREA LAYOUT SECTION	DWG		A04-18-77 04-20-77	ISSUED ISSUED	09-13-78	CONSTR	LO	ISSUED	OSBORNE
240-101	7	NHCAREA LAYOUT PLAN - 1ST FLR	DWG		A04-18-77 02-24-78	ISSUED ISSUED	12-21-78	CONSTR	LO	ISSUED	OSBORNE
240-102	10	NHCAREA LAYOUT PLAN - 2ND FLR	DWG		A04-18-77 02-24-78	ISSUED ISSUED	10-24-78	CONSTR	LO	ISSUED	OSBORNE
240-103	4	NHCAREA LAYOUT PLAN - ROOF	DWG		A04-18-77 02-24-78	ISSUED ISSUED	06-06-78	CONSTR	LO	ISSUED	OSBORNE
240-201	8	NHCAREA LAYOUT SECTION	DWG		A04-18-77 02-24-78	ISSUED ISSUED	12-21-78	CONSTR	LO	ISSUED	OSBORNE
240-202	6	NHCAREA LAYOUT SECTION	DWG		A04-18-77 02-24-78	ISSUED ISSUED	10-24-78	CONSTR	LO	ISSUED	OSBORNE

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*** LAYOUT DEPARTMENT ***

DOCUMENT	REV	TITLE	TYPE	CLIENT NO	C/A SCHED COMPLETE	LASTREPT EXPECTED COMPLETE	IN	STATUS	RESP	OUT	BY
240-203		NHCAREA LAYOUT SECTION	DWG		A04-18-77	ISSUED					
	6				02-24-78	ISSUED	06-06-78	CONSTR	LO	ISSUED	OSBORNE
250-101		UTILITY LAYOUT PLAN	DWG		A04-18-77	ISSUED					
	4				04-20-77	ISSUED	12-19-78	CONSTR	LO	ISSUED	OSBORNE
250-201		UTILITY LAYOUT SECTION	DWG		A04-18-77	ISSUED					
	6				04-20-77	ISSUED	12-19-78	CONSTR	LO	ISSUED	OSBORNE
251-101		COOLTWR LAYOUT PLAN & SECTION	DWG		A04-18-77	ISSUED					
	4				05-31-77	ISSUED	06-09-78	CONSTR	LO	ISSUED	OSBORNE
260-101		INCINR LAYOUT - PLAN	DWG		A03-31-78	ISSUED					
	5				03-01-78	ISSUED	12-27-78	CONSTR	LO	ISSUED	OSBORNE
260-201		INCINR LAYOUT - SECTION	DWG		A03-31-78	ISSUED					
	5				03-01-78	ISSUED	12-27-78	CONSTR	LO	ISSUED	OSBORNE
260-202		INCINR LAYOUT - SECTION	DWG		A03-31-78	ISSUED					
	2				03-01-78	ISSUED	12-27-78	CONSTR	LO	ISSUED	OSBORNE

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DOCUMENT REV	TITLE	TYPE CLIENT NO	C/A SCHED COMPLETE	LASTREPT EXPECTED COMPLETE	REMARK IN	STATUS	RESP	OUT	BY
M-1		SPEC	A02-08-77	ISSUED					
1	MECH EQUIPMENT SPECIFICATION		03-01-77	ISSUED	06-10-77	CONSTR	MECH	ISSUED	OSBORNE

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*** HVAC DEPARTMENT ***

DOCUMENT	REV	TITLE	TYPE	CLIENT NO	C/A SCHED COMPLETE	LASTREPT EXPECTED COMPLETE	REMARK IN	STATUS	RESP	OUT	BY
AH-15		MECHANICAL S/C	SPEC				10-10-78	DONE	HVAC	DONE	HODASZY
BH-15	0	MECHANICAL S/C	SPEC			ISSUED ISSUED	12-14-78	CONSTR	HVAC	ISSUED	OSBORNE
BH-15.5		ENV CONTROL S/C	SPEC				10-13-78	DONE	HVAC	DONE	HODASZY
EC-8		B10 AREA,	CALC				05-24-77	DONE	HVAC	DONE	HODASZY
EC-D		DRUM STORAGE	CALC				05-05-77	DONE	HVAC	DONE	HODASZY
EL-H		CHANGE HOUSE	CALC				04-13-77	DONE	HVAC	DONE	HODASZY
EC-N		NHC AREA	CALC				05-18-77	DONE	HVAC	DONE	HODASZY
EC-U		BOILER HOUSE	CALC				04-21-77	DONE	HVAC	DONE	HODASZY
H-1	1	HVAC BASIC	SPEC		A05-02-77 07-13-77	ISSUED ISSUED	05-02-78	CONSTR	HVAC	ISSUED	OSBORNE
H-15	1	MECHANICAL S/C	SPEC		A07-25-77 07-20-77	ISSUED ISSUED	05-01-78	CONSTR	HVAC	ISSUED	OSBORNE
H-15.5	1	ENV CONTROL S/C	SPEC		A08-31-77 07-13-77	ISSUED ISSUED	05-05-78	CONSTR	HVAC	ISSUED	OSBORNE
400-001	1	COVER SHEET	DWG		A08-05-77 06-15-77	ISSUED ISSUED	04-24-78	CONSTR	HVAC	ISSUED	OSBORNE
400-002	3	SYSTEMS DIAGRAM	DWG		A08-05-77 12-02-77	ISSUED ISSUED	10-06-78	CONSTR	HVAC	ISSUED	OSBORNE
400-003	2	SYSTEMS DIAGRAM	DWG		A08-05-77 12-02-77	ISSUED ISSUED	04-24-78	CONSTR	HVAC	ISSUED	OSBORNE
400-004	0	GUARD HOUSE SYS DIAG&FLOOR PLAN	DWG		A05-01-78 05-19-78	ISSUED ISSUED	05-24-78	CONSTR	HVAC	ISSUED	OSBORNE
400-005		COVER SHEET	DWG				10-10-78	DONE	HVAC	DONE	HODASZY
400-006		SYSTEMS DIAGRAM	DWG				10-10-78	DONE	HVAC	DONE	HODASZY

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*** HVAC DEPARTMENT ***

DOCUMENT	REV	TITLE	TYPE	CLIENT NO	C/A SCHED COMPLETE	LASTREPT EXPECTED COMPLETE ISSUED	REMARK IN	STATUS	RESP	OUT	BY
400-007	0	COVER SHEET	DWG		---------	ISSUED ISSUED	10-25-78	CONSTR	HVAC	ISSUED	OSBORNE
400-008	0	SYSTEMS DIAGRAM	DWG		---------	ISSUED ISSUED	10-25-78	CONSTR	HVAC	ISSUED	OSBORNE
400-009	0	SYSTEMS DIAGRAM	DWG		---------	ISSUED ISSUED	10-25-78	CONSTR	HVAC	ISSUED	OSBORNE
412-001	1	DRUMSTG PLAN & SECTIONS	DWG		A07-21-77	ISSUED ISSUED	10-25-78	CONSTR	HVAC	ISSUED	OSBORNE
415-001	1	CHANGEHS PLAN, SECTION & DETAILS	DWG		A08-05-77		11-09-77	DONE	HVAC	DONE	HUBER
420-001	1	YARD FIRE PUMP HOUSE-PLAN&SECTS	DWG		A05-01-78 03-10-78	ISSUED ISSUED	06-09-78	CONSTR	HVAC	ISSUED	OSBORNE
430-001	4	BIOAREA PLAN & SECTIONS	DWG		A08-05-77 03-10-78	ISSUED ISSUED	10-06-78	CONSTR	HVAC	ISSUED	OSBORNE
430-002	2	BIOAREA PLAN & SECTIONS	DWG		A08-05-77 03-10-78	ISSUED ISSUED	04-24-78	CONSTR	HVAC	ISSUED	OSBORNE
430-003	3	BIOAREA PLAN & SECTIONS	DWG		A08-05-77 03-10-78	ISSUED ISSUED	10-06-78	CONSTR	HVAC	ISSUED	OSBORNE
430-004	0	BIOAREA PLAN & SECTIONS	DWG		---------	ISSUED ISSUED	10-25-78	CONSTR	HVAC	ISSUED	OSBORNE
430-005	0	BIOAREA PLAN & SECTIONS	DWG		---------	ISSUED ISSUED	10-25-78	CONSTR	HVAC	ISSUED	OSBORNE
430-006	0	BIOAREA PLAN & SECTIONS	DWG		---------	ISSUED ISSUED	10-25-78	CONSTR	HVAC	ISSUED	OSBORNE
440-001	2	NHCAREA PLAN, SECTIONS & FLOORS	DWG		A08-05-77 05-31-77	ISSUED ISSUED	06-09-78	CONSTR	HVAC	ISSUED	OSBORNE
440-002	1	NHCAREA PLAN & SECTIONS - ROOF	DWG		A08-05-77 05-31-77	ISSUED ISSUED	04-24-78	CONSTR	HVAC	ISSUED	OSBORNE
440-003	1	NHCAREA SECTIONS & DETAILS	DWG		A08-05-77 05-31-77	ISSUED ISSUED	04-24-78	CONSTR	HVAC	ISSUED	OSBORNE
440-004	1	NHCAREA SECTIONS	DWG		A08-05-77 05-31-77	ISSUED ISSUED	04-24-78	CONSTR	HVAC	ISSUED	OSBORNE
450-001	1	UTILITY PLAN, SECTION & DETAILS	DWG		A07-21-77 06-24-77	ISSUED ISSUED	04-24-78	CONSTR	HVAC	ISSUED	OSBORNE

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*** INSTRUMENT DEPARTMENT ***

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C-01			SPEC		A03-29-77	ISSUED					
	0	INSTR DESIGN BASIS			04-22-77	ISSUED	04-22-77	CONSTR	INSTR	ISSUED	OSBORNE
C-04			SPEC		A06-23-77	ISSUED					
	0	PREFABRICATED INSTRUMENT PANELS			08-09-77	ISSUED	08-09-77	CONSTR	INSTR	ISSUED	OSBORNE
C-07			SPEC		A08-31-77	ISSUED					
	1	INSTR MATERIAL			09-22-77	ISSUED	06-14-78	CONSTR	INSTR	ISSUED	OSBORNE
C-09			SPEC			ISSUED					
	1	INSTRUMENT ITEM INDEX				ISSUED	11-28-78	CONSTR	INSTR	ISSUED	OSBORNE
C-10			SPEC		A02-23-77	ISSUED					
	0	HAZARD SPEC			03-10-77	ISSUED	03-10-77	CONSTR	INSTR	ISSUED	OSBORNE
CAL-01			CALC								
		RELIEF HEADERS					06-21-77	DONE	INSTR	DONE	VANCE
600-001			PARGMT		A05-23-77	ISSUED					
	2	IP 1 TO 7			12-16-77	ISSUED	11-01-78	CONSTR	INSTR	ISSUED	OSBORNE
600-002			PARGMT		A05-23-77	ISSUED					
	2	IP 8 & 9			12-16-77	ISSUED	11-01-78	CONSTR	INSTR	ISSUED	OSBORNE
600-003			PARGMT		A06-09-77	ISSUED					
	2	IP-1 THRU IP-9 ARRGMT & FABR			12-16-77	ISSUED	11-01-78	CONSTR	INSTR	ISSUED	OSBORNE
600-004			PARGMT		A09-13-77	ISSUED					
	3	INTRINSIC SAFETY BARRIER CABINET			03-31-78	ISSUED	12-07-78	CONSTR	INSTR	ISSUED	OSBORNE
610-001			IDTL		A09-07-77	ISSUED					
	0	INSTALLATION DETAIL			07-20-77	ISSUED	09-20-77	CONSTR	INSTR	ISSUED	OSBORNE
610-002			IDTL		A09-07-77	ISSUED					
	0	INSTALLATION DETAIL			07-20-77	ISSUED	09-20-77	CONSTR	INSTR	ISSUED	OSBORNE
610-003			IDTL		A09-07-77	ISSUED					
	0	INSTALLATION DETAIL			07-20-77	ISSUED	09-20-77	CONSTR	INSTR	ISSUED	OSBORNE
610-004			IDTL		A09-07-77	ISSUED					
	0	INSTALLATION DETAIL			07-20-77	ISSUED	09-20-77	CONSTR	INSTR	ISSUED	OSBORNE
610-005			IDTL		A09-07-77	ISSUED					
	0	INSTALLATION DETAIL			07-20-77	ISSUED	09-20-77	CONSTR	INSTR	ISSUED	OSBORNE
610-006			IDTL		A09-07-77	ISSUED					
	0	INSTALLATION DETAIL			07-20-77	ISSUED	09-20-77	CONSTR	INSTR	ISSUED	OSBORNE
610-008			IDTL		A09-07-77	ISSUED					
	0	INSTALLATION DETAIL			07-20-77	ISSUED	09-20-77	CONSTR	INSTR	ISSUED	OSBORNE

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610-009	0	INSTALLATION DETAIL	IDTL		A09-07-77 07-20-77	ISSUED ISSUED	09-20-77	CONSTR	INSTR	ISSUED	OSBORNE
610-010	0	INSTALLATION DETAIL	IDTL		A09-07-77 07-20-77	ISSUED ISSUED	09-20-77	CONSTR	INSTR	ISSUED	OSBORNE
610-011	0	INSTALLATION DETAIL	IDTL		A09-07-77 07-20-77	ISSUED ISSUED	09-20-77	CONSTR	INSTR	ISSUED	OSBORNE
610-012	0	INSTALLATION DETAIL	IDTL		A09-07-77 07-20-77	ISSUED ISSUED	09-20-77	CONSTR	INSTR	ISSUED	OSBORNE
610-013	0	INSTALLATION DETAIL	IDTL		A09-07-77 07-20-77	ISSUED ISSUED	09-20-77	CONSTR	INSTR	ISSUED	OSBORNE
610-014	0	INSTALLATION DETAIL	IDTL		A09-07-77 07-20-77	ISSUED ISSUED	09-20-77	CONSTR	INSTR	ISSUED	OSBORNE
610-015	0	INSTALLATION DETAIL	IDTL		A09-07-77 07-20-77	ISSUED ISSUED	09-20-77	CONSTR	INSTR	ISSUED	OSBORNE
610-016	0	INSTALLATION DETAIL	IDTL		A09-07-77 07-20-77	ISSUED ISSUED	09-20-77	CONSTR	INSTR	ISSUED	OSBORNE
610-017	0	INSTALLATION DETAIL	IDTL		A09-07-77 07-20-77	ISSUED ISSUED	09-20-77	CONSTR	INSTR	ISSUED	OSBORNE
610-018	0	INSTALLATION DETAIL	IDTL		A09-07-77 07-20-77	ISSUED ISSUED	09-20-77	CONSTR	INSTR	ISSUED	OSBORNE
610-019	0	INSTALLATION DETAIL	IDTL		A09-07-77 07-20-77	ISSUED ISSUED	09-20-77	CONSTR	INSTR	ISSUED	OSBORNE
610-020	0	INSTALLATION DETAIL	IDTL		A09-07-77 07-20-77	ISSUED ISSUED	09-20-77	CONSTR	INSTR	ISSUED	OSBORNE
610-021	0	INSTALLATION DETAIL	IDTL		A09-07-77 07-20-77	ISSUED ISSUED	09-20-77	CONSTR	INSTR	ISSUED	OSBORNE
610-022	0	INSTALLATION DETAIL	IDTL		A09-07-77 07-20-77	ISSUED ISSUED	09-20-77	CONSTR	INSTR	ISSUED	OSBORNE
610-023	0	INSTALLATION DETAIL	IDTL		A09-07-77 07-20-77	ISSUED ISSUED	09-20-77	CONSTR	INSTR	ISSUED	OSBORNE
610-099	1	ELECTRICAL INSTR CONNECTIONS	IDTL		A07-20-77 08-09-77	ISSUED ISSUED	08-09-77	CONSTR	INSTR	ISSUED	OSBORNE
620-001	1	LEGEND & NOTES	ICD		A05-13-77 06-14-77	ISSUED ISSUED	12-15-77	CONSTR	INSTR	ISSUED	OSBORNE

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621-001	2	RAW MATERIAL STORAGE	ICD		A05-02-77 12-02-77	ISSUED ISSUED	12-07-78	CONSTR	INSTR	ISSUED	OSBORNE
621-002	3	RAW MATERIAL STORAGE DRUMS	ICD		A05-13-77 12-02-77	ISSUED ISSUED	12-07-78	CONSTR	INSTR	ISSUED	OSBORNE
623-001	2	B10 PRODUCTION	ICD		A05-13-77 12-02-77	ISSUED ISSUED	11-01-78	CONSTR	INSTR	ISSUED	OSBORNE
623-002	3	PRODUCT FILTER	ICD		A05-13-77 12-02-77	ISSUED ISSUED	12-07-78	CONSTR	INSTR	ISSUED	OSBORNE
624-001	3	NHC PRODUCTION	ICD		A05-13-77 12-02-77	ISSUED ISSUED	12-07-78	CONSTR	INSTR	ISSUED	OSBORNE
625-001	2	UTILITIES AREA	ICD		A05-13-77 12-02-77	ISSUED ISSUED	12-07-78	CONSTR	INSTR	ISSUED	OSBORNE
626-001	2	DIAGRAM, WASTE DISPOSAL	ICD		A12-28-77 03-17-78	ISSUED ISSUED	12-07-78	CONSTR	INSTR	ISSUED	OSBORNE
627-001	0	OFF SITES	ICD		A05-04-78	ISSUED ISSUED	06-13-78	CONSTR	INSTR	ISSUED	OSBORNE
630-001	0	TK FARM AREA	IARGMT			ISSUED ISSUED	11-27-78	CONSTR	INSTR	ISSUED	OSBORNE
650-001	A	SHEET 1	PTD				04-20-77	DONE	INSTR	DONE	VANCE
650-002	A	SHEET 2	PTD				04-20-77	DONE	INSTR	DONE	VANCE
650-003	A	SHEET 3	PTD				04-20-77	DONE	INSTR	DONE	VANCE
650-004	A	SHEET 4	PTD				04-20-77	DONE	INSTR	DONE	VANCE
650-005	A	SHEET 5	PTD				04-20-77	DONE	INSTR	DONE	VANCE
690-001	3	IP-1 THRU IP-7	PWD		A06-23-77 11-18-77	ISSUED ISSUED	11-01-78	CONSTR	INSTR	ISSUED	OSBORNE
690-002	2	IP-1 THRU IP-7	PWD		A06-23-77 11-18-77	ISSUED ISSUED	11-01-78	CONSTR	INSTR	ISSUED	OSBORNE

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DOCUMENT	REV	TITLE	TYPE	CLIENT NO	C/A SCHED COMPLETE	LASTREPT EXPECTED COMPLETE	REMARK IN	STATUS	RESP	OUT	BY
M730-001		BIOAREA MODEL (PROCESS)	MODEL		A08-05-77		05-31-78	DONE	MODEL	DONE	LIZANICH
M730-002		BIOAREA MODEL REACTOR AREA	MODEL				05-31-78	DONE	MODEL	DONE	LIZANICH
M740-001		NHCAREA MODEL	MODEL				05-31-78	DONE	MODEL	DONE	LIZANICH
M760-001		INCINERATOR MODEL	MODEL				WILL BE ISSD W/HLD ON OXIDIZER 05-31-78	DONE	MODEL	DONE	LIZANICH
PLI&IL	4	PIPING LINE INDEX & INSUL LIST	LIST		....	ISSUED ISSUED	01-09-79	CONSTR	PIPNG	ISSUED	OSBORNE
170-201	4	STEAM & COND	URD		A08-15-77 12-02-77	ISSUED ISSUED	01-19-79	CONSTR	PIPNG	ISSUED	OSBORNE
170-202	3	POTABLE WATER&FIRE WATER SYSTEM	URD		A08-15-77 12-02-77	ISSUED ISSUED	12-11-78	CONSTR	PIPNG	ISSUED	OSBORNE
170-204	4	CHILLED COOLING WATER SYSTEM	URD		A08-15-77 12-02-77	ISSUED ISSUED	01-04-79	CONSTR	PIPNG	ISSUED	OSBORNE
170-205	3	COOLING WATER SYSTEM	URD		A08-15-77 12-02-77	ISSUED ISSUED	12-11-78	CONSTR	PIPNG	ISSUED	OSBORNE
170-206	3	INSTRUMENT AIR&BREATHING AIR SYS	URD		A08-15-77 12-02-77	ISSUED ISSUED	12-11-78	CONSTR	PIPNG	ISSUED	OSBORNE
170-207	2	NITROGEN SYSTEM	URD		A08-15-77 12-02-77	ISSUED ISSUED	10-24-78	CONSTR	PIPNG	ISSUED	OSBORNE
170-208	2	WASH VENT SYSTEM	URD		A08-15-77 12-02-77	ISSUED ISSUED	10-24-78	CONSTR	PIPNG	ISSUED	OSBORNE
170-209	2	NHCAREA VENT SYS&HIGH VELOCITY VENT SYS	URD		A08-15-77 12-02-77	ISSUED ISSUED	10-24-78	CONSTR	PIPNG	ISSUED	OSBORNE
170-210	2	BIOAREA VENT SYSTEM	URD		A08-15-77 12-02-77	ISSUED ISSUED	10-24-78	CONSTR	PIPNG	ISSUED	OSBORNE
700-001	0	MISC PIPING & GENERAL NOTES	DWG		A07-20-77 08-05-77	ISSUED ISSUED	08-06-77	CONSTR	PIPNG	ISSUED	OSBORNE
700-002	0	PIPE SUP DTL/HOT INSLTD LINES	DWG		09-08-77	ISSUED ISSUED	09-08-77	CONSTR	PIPNG	ISSUED	OSBORNE
700-003	0	PRESS SAFETY DEVICE SUP&MISC DTL	DWG		09-08-77	ISSUED ISSUED	09-08-77	CONSTR	PIPNG	ISSUED	OSBORNE

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700-004	0	PIPE SUP DTLS	DWG		09-08-77	ISSUED	09-08-77	CONSTR	PIPNG	ISSUED	OSBORNE
700-010	0	YARD EXISTING PLANT PIPING PLAN&SECTS	DWG		A07-06-78 05-24-78	ISSUED ISSUED	08-07-78	CONSTR	PIPNG	ISSUED	OSBORNE
700-011	3	YARD GUARD HOUSE PLUMBING-PLAN&SECTS	DWG		A09-23-77 10-24-77	ISSUED ISSUED	12-22-78	CONSTR	PIPNG	ISSUED	OSBORNE
700-012	0	YARD EXISTING PLANT-PIPING PLAN&SECTS	DWG		A07-06-78	ISSUED ISSUED	08-07-78	CONSTR	PIPNG	ISSUED	OSBORNE
711-101	3	TKFARM PIPING PLAN	DWG		A07-20-77 06-16-78	ISSUED ISSUED	10-31-78	CONSTR	PIPNG	ISSUED	OSBORNE
711-141	4	TKFARM PIPING SECT	DWG		A07-20-77	ISSUED ISSUED	12-22-78	CONSTR	PIPNG	ISSUED	OSBORNE
712-101	3	DRUMSTG PIPING PLAN & SECT	DWG		A07-20-77	ISSUED ISSUED	12-11-78	CONSTR	PIPNG	ISSUED	OSBORNE
715-101	0	CHANGEHS PIPING PLAN & ISOMETRIC	DWG		A02-02-79	02-15-79 ISSUED	02-07-79	CONSTR	PIPNG	ISSUED	OSBORNE
715-101			DWG		....	....					
715-181	3	CHANGEHS PLUMBING PLAN	DWG		A12-28-77 06-27-77	ISSUED ISSUED	01-11-79	CONSTR	PIPNG	ISSUED	OSBORNE
715-182	2	CHANGEHS PLUMBING SECTIONS	DWG		A12-28-77 06-27-77	ISSUED ISSUED	12-22-78	CONSTR	PIPNG	ISSUED	OSBORNE
716-101	6	SERVRACK PIPING PLAN & SECTS	DWG		A08-05-77 05-12-78	ISSUED ISSUED	12-22-78	CONSTR	PIPNG	ISSUED	OSBORNE
716-102	2	SERVRACK PIPING PLAN & SECTS	DWG		A09-23-77 08-09-77	ISSUED ISSUED	10-17-78	CONSTR	PIPNG	ISSUED	OSBORNE
716-103	6	SERVRACK PIPING PLAN & SECTS	DWG		A08-05-77 05-12-78	ISSUED ISSUED	10-17-78	CONSTR	PIPNG	ISSUED	OSBORNE
716-104	5	SERVRACK PIPING PLAN & SECTS	DWG		A08-05-77 05-12-78	ISSUED ISSUED	12-22-78	CONSTR	PIPNG	ISSUED	OSBORNE
716-105	4	SERVRACK PIPING PLAN & SECTS	DWG		A08-05-77 05-12-78	ISSUED ISSUED	10-17-78	CONSTR	PIPNG	ISSUED	OSBORNE
720-101	3	YARD FIRE PUMP HOUSE PLAN&SECTS	DWG		A02-17-78 04-07-78	ISSUED ISSUED	07-27-78	CONSTR	PIPNG	ISSUED	OSBORNE

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720-102		YARD	DWG		A02-17-78	ISSUED					
	2	FRWTR PMP HS UNDRSLB PIPNG PL&DT			....	ISSUED	07-27-78	CONSTR	PIPNG	ISSUED	OSBORNE
730-101		BIOAREA	DWG		A08-05-77	ISSUED					
	6	PIPE RACKS - PIPING PLAN			03-17-78	ISSUED	12-11-78	CONSTR	PIPNG	ISSUED	OSBORNE
730-102		BIOAREA	DWG		A09-13-77	ISSUED					
	3	UNDERSLAB PIPING PLAN&SECTS			03-17-78	ISSUED	07-21-78	CONSTR	PIPNG	ISSUED	OSBORNE
730-103		BIOAREA	DWG		A09-29-77	ISSUED					
	2	PIPING PLAN SECT & ISOS			10-24-77	ISSUED	06-13-78	CONSTR	PIPNG	ISSUED	OSBORNE
730-104		BIOAREA	DWG		A12-09-77	ISSUED					
	3	1ST FLR SERV RACK-PIPNG PLN&SECT			03-03-78	ISSUED	10-31-78	CONSTR	PIPNG	ISSUED	OSBORNE
730-141		BIOAREA	DWG		A08-05-77	ISSUED					
	4	PIPE RACKS - PIPING SECTS&DTLS			03-17-78	ISSUED	10-26-78	CONSTR	PIPNG	ISSUED	OSBORNE
730-181		BIOAREA	DWG		A09-13-77	ISSUED					
	2	PLUMB & INSTR AIR PLAN&ISOS			10-12-77	ISSUED	06-13-78	CONSTR	PIPNG	ISSUED	OSBORNE
730-201		BIOAREA	ISOS			ISSUED					
	0	ISO'S (180)			03-17-78	ISSUED	06-07-78	CONSTR	ISOS	ISSUED	OSBORNE
740-101		NHCAREA	DWG		A09-23-77	ISSUED					
	5	PIPE RACKS - PIPING PLAN			04-21-78	ISSUED	12-11-78	CONSTR	PIPNG	ISSUED	OSBORNE
740-102		NHCAREA	DWG		A09-13-77	ISSUED					
	2	UNDERSLAB PIPING PLAN&DETL			10-04-77	ISSUED	04-18-78	CONSTR	PIPNG	ISSUED	OSBORNE
740-103		NHCAREA	DWG		A10-10-77	ISSUED					
	2	H&V PIPING PLAN & SECTIONS			10-24-77	ISSUED	06-07-78	CONSTR	PIPNG	ISSUED	OSBORNE
740-104		NHCAREA	DWG		A09-13-77	ISSUED					
	4	1ST FLR SERVICE RACK-PIPING PLAN			04-21-78	ISSUED	12-11-78	CONSTR	PIPNG	ISSUED	OSBORNE
740-141		NHCAREA	DWG		A09-23-77	ISSUED					
	2	PIPE RACKS-PIPING SECTS&DTLS			04-21-78	ISSUED	02-15-78	CONSTR	PIPNG	ISSUED	OSBORNE
740-181		NHCAREA	DWG		A10-10-77	ISSUED					
	2	PLUMBING PLAN & ISOMETRIC			10-24-77	ISSUED	12-11-78	CONSTR	PIPNG	ISSUED	OSBORNE
740-201		NHCAREA	ISOS			ISSUED					
	0	ISO'S (180)			....	ISSUED	03-29-78	CONSTR	ISOS	ISSUED	OSBORNE
750-101		UTILITY	DWG		A09-13-77	ISSUED					
	4	PIPING PLAN			05-26-78	ISSUED	01-04-79	CONSTR	PIPNG	ISSUED	OSBORNE
750-141		UTILITY	DWG		A09-13-77	ISSUED					
	4	PIPING SECT			05-26-78	ISSUED	01-04-79	CONSTR	PIPNG	ISSUED	OSBORNE

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750-142	3	UTILITY PIPING SECT	DWG		A09-13-77 05-26-78	ISSUED ISSUED	12-22-78	CONSTR	PIPNG	ISSUED	OSBORNE
750-181	2	UTILITY PLUMBING - PLAN & ISOMETRIC	DWG		A09-13-77 10-12-77	ISSUED ISSUED	06-09-78	CONSTR	PIPNG	ISSUED	OSBORNE
750-182	1	UTILITY UNDERSLAB PIPING PLAN & DETAILS	DWG		A10-10-77 10-12-77	ISSUED ISSUED	06-13-78	CONSTR	PIPNG	ISSUED	OSBORNE
751-101	2	COOLTWR PIPING PLAN	DWG		A07-20-77 07-07-77	ISSUED ISSUED	02-15-78	CONSTR	PIPNG	ISSUED	OSBORNE
760-101	2	INCINR PIPING PLAN	DWG		A05-26-78 04-14-78	ISSUED ISSUED	12-22-78	CONSTR	PIPNG	ISSUED	OSBORNE
760-102		INCINR	DWG				05-16-78	SPARE	PIPNG		LIZANICH
760-141	2	INCINR PIPING SECT	DWG		A05-26-78 05-12-78	ISSUED ISSUED	12-22-78	CONSTR	PIPNG	ISSUED	OSBORNE
760-142	2	INCINR PIPING SECT	DWG		A05-26-78 05-12-78	ISSUED ISSUED	12-22-78	CONSTR	PIPNG	ISSUED	OSBORNE
760-143		INCINR	DWG				04-10-78	SPARE	PIPNG		LIZANICH

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EIL	1	EQUIPMENT INSULATION LIST	LIST			ISSUED	11-01-78	CONSTR	MTO	ISSUED	OSBORNE
J-1	1	THERMAL INSULATION	SPEC		A11-09-77 01-13-78	ISSUED ISSUED	06-08-78	CONSTR	MTO	ISSUED	OSBORNE
P-1	5	PIPING MATERIALS	SPEC		A05-20-77 05-12-77	ISSUED ISSUED	01-18-79	CONSTR	MTO	ISSUED	OSBORNE
P-2	1	PIPING FABRICATION	SPEC		A07-20-77 05-12-77	ISSUED ISSUED	06-20-78	CONSTR	MTO	ISSUED	OSBORNE
PTR	2	PRESSURE TESTING REPORT	REPORT		[illegible]	ISSUED ISSUED	11-02-78	CONSTR	MTO	ISSUED	OSBORNE
Q-1	3	PLUMBING SPEC	SPEC		A04-12-77 04-29-77	ISSUED ISSUED	10-02-78	CONSTR	MTO	ISSUED	OSBORNE

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DOCUMENT	REV	TITLE	TYPE	CLIENT NO	C/A SCHED	LASTREPT	SCHED COMPLETE	EXPECTED COMPLETE	REMARK IN	STATUS	RESP	OUT	BY
BS-G1	0	BASIC SPECIFICATION	SPEC		A02-01-77	ISSUED	08-10-77	ISSUED	02-16-77	CONSTR	ARCH	ISSUED	OSBORNE
R04.101	3	CONCRETE MASONRY	SPEC		A06-02-77	ISSUED	09-16-77	ISSUED	08-03-78	CONSTR	ARCH	ISSUED	OSBORNE
R05.201	0	METAL ROOF DECKING	SPEC		A06-23-77	ISSUED	08-10-77	ISSUED	07-29-77	CONSTR	ARCH	ISSUED	OSBORNE
R07.102	1	AREA INS - MIN BOARD STEEL DECK	SPEC		A08-05-77	ISSUED	08-10-77	ISSUED	06-22-78	CONSTR	ARCH	ISSUED	OSBORNE
R07.106	0	BLDG INSUL-SEMI-REGID FIBERGLASS	SPEC		A08-05-77	ISSUED	08-19-77	ISSUED	08-19-77	CONSTR	ARCH	ISSUED	OSBORNE
R07.202	0	BUILT UP ROOFING RAG FELT	SPEC		A09-29-77	ISSUED	10-21-77	ISSUED	10-21-77	CONSTR	ARCH	ISSUED	OSBORNE
R07.204	1	LAMINATED MEMBRANE ROOFING	SPEC		A06-02-77	ISSUED	07-06-77	ISSUED	07-06-77	CONSTR	ARCH	ISSUED	OSBORNE
R07.205	1	PENETRATION MEMBRANE ROOFING	SPEC		A06-23-77	ISSUED	09-16-77	ISSUED	09-16-77	CONSTR	ARCH	ISSUED	OSBORNE
R07.306	3	PREFIN STL SIDING & ROOFING	SPEC		A08-05-77	ISSUED	08-10-77	ISSUED	01-31-78	CONSTR	ARCH	ISSUED	OSBORNE
R07.401	1	SHEET METAL FLASHING	SPEC		A06-23-77	ISSUED	08-10-77	ISSUED	08-03-78	CONSTR	ARCH	ISSUED	OSBORNE
R07.501	0	ELASTIC FLASHING-NEOPRENE	SPEC		A06-02-77	ISSUED	08-10-77	ISSUED	06-24-77	CONSTR	ARCH	ISSUED	OSBORNE
R07.601	2	GUTTERS & DOWNSPOUTS	SPEC		A06-02-77	ISSUED	08-10-77	ISSUED	03-02-78	CONSTR	ARCH	ISSUED	OSBORNE
R07.701	0	CAULKING & SEALANTS	SPEC		A06-02-77	ISSUED	08-10-77	ISSUED	06-24-77	CONSTR	ARCH	ISSUED	OSBORNE
R08.101	2	HOLLOW MTL DOORS&FRAMES CORE RE	SPEC		A08-09-77	ISSUED	08-10-77	ISSUED	05-05-78	CONSTR	ARCH	ISSUED	OSBORNE
R08.301	0	OVERHEAD DOORS	SPEC		A06-02-77	ISSUED	06-24-77	ISSUED	06-24-77	CONSTR	ARCH	ISSUED	OSBORNE
R08.501	2	FINISH HARDWARE	SPEC		A08-09-77	ISSUED	....	ISSUED	03-15-78	CONSTR	ARCH	ISSUED	OSBORNE
R08.502	0	LOCK CYLINDERS	SPEC		A06-02-77	ISSUED	08-10-77	ISSUED	06-24-77	CONSTR	ARCH	ISSUED	OSBORNE

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R08.601	0	ALUMINUM WINDOWS-PROJECTED	SPEC		A08-05-77 08-10-77	ISSUED ISSUED	08-19-77	CONSTR	ARCH	ISSUED	OSBORNE
R08.701	2	GLASS & GLAZING	SPEC		A06-02-77 08-10-77	ISSUED ISSUED	11-07-78	CONSTR	ARCH	ISSUED	OSBORNE
R08.801	1	WEATHERSTRIPPING	SPEC		A06-02-77 08-10-77	ISSUED ISSUED	09-16-77	CONSTR	ARCH	ISSUED	OSBORNE
R09.101	1	VINYL ASB TILE FLOORING	SPEC		A06-02-77 08-10-77	ISSUED ISSUED	09-16-77	CONSTR	ARCH	ISSUED	OSBORNE
R09.103	0	CERAMIC TILE FLOORS-DRY SET	SPEC		A06-02-77 08-10-77	ISSUED ISSUED	06-24-77	CONSTR	ARCH	ISSUED	OSBORNE
R09.202	0	PREFIN HDBD DRY WALL SYSTEM	SPEC		A06-07-77 08-10-77	ISSUED ISSUED	06-24-77	CONSTR	ARCH	ISSUED	OSBORNE
R09.603	1	LAY-IN ACOUSTICAL TILE CEILING	SPEC		A07-25-77 08-10-77	ISSUED ISSUED	10-23-78	CONSTR	ARCH	ISSUED	OSBORNE
R09.701	1	PAINTING-MATERIALS & WORKMANSHIP	SPEC		A08-31-77 08-10-77	ISSUED ISSUED	10-03-77	CONSTR	ARCH	ISSUED	OSBORNE
R09.704	2	PAINTING-GENERAL PAINTING	SPEC		A08-31-77 08-10-77	ISSUED ISSUED	06-20-78	CONSTR	ARCH	ISSUED	OSBORNE
R09.801	0	FIREPROOFING MASTIC	SPEC		A08-09-77 08-10-77	ISSUED ISSUED	08-19-77	CONSTR	ARCH	ISSUED	OSBORNE
R09.900	2	EQUIPMENT SURFACE PREP & PRIMING	SPEC		A06-02-77	ISSUED ISSUED	10-03-77	CONSTR	ARCH	ISSUED	OSBORNE
R10.102	0	MTL TOILET PART-FLUSH FL MTL BRC	SPEC		A05-25-77 08-10-77	ISSUED ISSUED	06-24-77	CONSTR	ARCH	ISSUED	OSBORNE
R10.201	0	LOCKERS & BENCHES	SPEC		A06-02-77 08-10-77	ISSUED ISSUED	06-24-77	CONSTR	ARCH	ISSUED	OSBORNE
R10.202	0	TOILET ROOM ACCESSORIES	SPEC		A06-23-77 08-10-77	ISSUED ISSUED	07-29-77	CONSTR	ARCH	ISSUED	OSBORNE
R10.203	1	METAL SHOWER ENCLOSURE	SPEC		A06-02-77 10-14-77	ISSUED ISSUED	10-14-77	CONSTR	ARCH	ISSUED	OSBORNE
R13.202	0	PRE-ENGINEERED BLDG FR	SPEC		A08-09-77 08-19-77	ISSUED ISSUED	08-19-77	CONSTR	ARCH	ISSUED	OSBORNE
SC-1	0	SPECIAL CONDITIONS	CONTR DOC		A10-10-77 10-21-77	ISSUED ISSUED	10-21-77	CONSTR	ARCH	ISSUED	OSBORNE

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S02.604	0	DRILLED CONCRETE CAISSONS	SPEC		A01-17-78	ISSUED	02-10-78	ISSUED	02-14-78	CONSTR	ARCH	ISSUED	OSBORNE
S03.101	1	CAST-IN-PLACE CONCRETE	SPEC		A06-02-77	ISSUED	08-10-77	ISSUED	09-16-77	CONSTR	ARCH	ISSUED	OSBORNE
S05.101	4	STRUCTURAL METAL	SPEC		A06-02-77	ISSUED	08-10-77	ISSUED	07-25-78	CONSTR	ARCH	ISSUED	OSBORNE
S05.102	4	MISCELLANEOUS METAL	SPEC		A06-02-77	ISSUED	08-10-77	ISSUED	07-25-78	CONSTR	ARCH	ISSUED	OSBORNE
S05.103	0	STEEL JOISTS	SPEC		A11-29-77	ISSUED	11-30-77	ISSUED	11-23-77	CONSTR	CUST	ISSUED	OSBORNE
T02.202	0	CLEARING & GRUBBING	SPEC		A07-25-77	ISSUED	08-10-77	ISSUED	08-04-77	CONSTR	ARCH	ISSUED	OSBORNE
T02.301	1	ROUGH GRADING	SPEC		A08-05-77	ISSUED	08-10-77	ISSUED	09-16-77	CONSTR	ARCH	ISSUED	OSBORNE
T02.303	1	FILLS & EMBANKMENTS	SPEC		A08-05-77	ISSUED	08-10-77	ISSUED	09-16-77	CONSTR	ARCH	ISSUED	OSBORNE
T02.304	1	EXCAV FILL & BKFILL STR	SPEC		A08-05-77	ISSUED	08-10-77	ISSUED	09-16-77	CONSTR	ARCH	ISSUED	OSBORNE
T02.305	1	EXCAV BEDNG & BKFILL SEWERS	SPEC		A08-05-77	ISSUED	08-10-77	ISSUED	09-16-77	CONSTR	ARCH	ISSUED	OSBORNE
T02.501	1	PREP OF SUBGRADE	SPEC		A08-05-77	ISSUED	08-10-77	ISSUED	09-16-77	CONSTR	ARCH	ISSUED	OSBORNE
T02.503	0	DENSE GRD AGGR BASE COURSE	SPEC		A08-05-77	ISSUED	08-10-77	ISSUED	08-19-77	CONSTR	ARCH	ISSUED	OSBORNE
T02.504	0	BITUM PRIME COAT	SPEC		A08-05-77	ISSUED	08-10-77	ISSUED	08-19-77	CONSTR	ARCH	ISSUED	OSBORNE
T02.506	1	DENSE GRD HOT LAID PLANT MIX	SPEC		A08-05-77	ISSUED	08-10-77	ISSUED	09-16-77	CONSTR	ARCH	ISSUED	OSBORNE
T02.508	0	CONCRETE PAV & SIDEWALKS	SPEC		A09-22-77	ISSUED	10-10-77	ISSUED	10-10-77	CONSTR	ARCH	ISSUED	OSBORNE
T02.509	0	SHOULDERS FOR ROADS	SPEC		A08-09-77	ISSUED	08-19-77	ISSUED	08-19-77	CONSTR	ARCH	ISSUED	OSBORNE
T02.701	1	FINISH GRADING	SPEC		A08-05-77	ISSUED	08-10-77	ISSUED	09-16-77	CONSTR	ARCH	ISSUED	OSBORNE

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T02.705	1	STEEL CHAIN LINK FENCE	SPEC		A06-23-77 08-10-77	ISSUED ISSUED	09-16-77	CONSTR	ARCH	ISSUED	OSBORNE
800-000	2	DWG INDEX & SPEC NOTES	DWG		12-30-77	ISSUED ISSUED	09-29-78	CONSTR	ARCH	ISSUED	OSBORNE
800-101	8	PROJECT DOOR SCHEDULE	DWG		A08-31-77	ISSUED ISSUED	09-29-78	CONSTR	ARCH	ISSUED	OSBORNE
800-102	4	PROJECT ROOM FIN SCHED&CLG PLANS	DWG		A08-31-77 09-30-77	ISSUED ISSUED	09-29-78	CONSTR	ARCH	ISSUED	OSBORNE
800-105	7	GUARDHOUSE PLANS & ELEVATIONS	DWG		A08-13-77 11-15-77	ISSUED ISSUED	09-18-78	CONSTR	ARCH	ISSUED	OSBORNE
800-106	8	GUARDHOUSE SECTIONS & DETAILS	DWG		A09-13-77 10-26-77	ISSUED ISSUED	09-22-78	CONSTR	ARCH	ISSUED	OSBORNE
812-101	5	DRUMSTG FLOOR PLAN & ROOF AREA	DWG		A06-23-77 06-02-77	ISSUED ISSUED	10-10-78	CONSTR	ARCH	ISSUED	OSBORNE
812-131	5	DRUMSTG ELEVATIONS	DWG		A06-23-77 06-02-77	ISSUED ISSUED	10-02-78	CONSTR	ARCH	ISSUED	OSBORNE
815-101	4	CHANGEHS FLOOR PLAN & ROOF PLAN	DWG		A09-19-77	ISSUED ISSUED	10-10-78	CONSTR	ARCH	ISSUED	OSBORNE
815-131	2	CHANGEHS AREA ELEVATIONS	DWG		A09-19-77	ISSUED ISSUED	07-19-78	CONSTR	ARCH	ISSUED	OSBORNE
815-132	3	CHANGEHS SECTIONS & DETAILS	DWG		A09-19-77	ISSUED ISSUED	09-29-78	CONSTR	ARCH	ISSUED	OSBORNE
820-101	1	YARD FIRE PUMP HOUSE PLAN	DWG		A03-13-78 03-10-78	ISSUED ISSUED	05-09-78	CONSTR	ARCH	ISSUED	OSBORNE
830-101	3	BIOAREA FLOOR PLAN & ROOF PLAN	DWG		A08-31-77 06-22-77	ISSUED ISSUED	07-19-78	CONSTR	ARCH	ISSUED	OSBORNE
830-131	3	BIOAREA ELEVATIONS	DWG		A08-31-77 06-22-77	ISSUED ISSUED	07-19-78	CONSTR	ARCH	ISSUED	OSBORNE
830-132	5	BIOAREA SECTIONS & DETAILS	DWG		A08-31-77 06-22-77	ISSUED ISSUED	09-29-78	CONSTR	ARCH	ISSUED	OSBORNE
830-133	4	BIOAREA DETAIL OFFICE PLAN	DWG		A08-31-77 06-22-77	ISSUED ISSUED	09-29-78	CONSTR	ARCH	ISSUED	OSBORNE
830-134	2	BIOAREA STAIR PLANS, SECTIONS & DETAILS	DWG		A08-31-77 06-22-77	ISSUED ISSUED	02-02-78	CONSTR	ARCH	ISSUED	OSBORNE

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DOCUMENT	REV	TITLE	TYPE	CLIENT NO	C/A SCHED COMPLETE	LASTREPT EXPECTED COMPLETE	IN	STATUS	RESP	OUT	BY
830-135	3	B10AREA SECTS & DETLS	DWG		A08-31-77 / 06-22-77	ISSUED / ISSUED	07-19-78	CONSTR	ARCH	ISSUED	OSBORNE
840-101	3	NHCAREA FLOOR PLAN & ROOF PLAN	DWG		A08-10-77 / 06-21-77	ISSUED / ISSUED	02-02-78	CONSTR	ARCH	ISSUED	OSBORNE
840-131	2	NHCAREA ELEVATIONS	DWG		A08-10-77 / 06-21-77	ISSUED / ISSUED	02-02-78	CONSTR	ARCH	ISSUED	OSBORNE
840-132	3	NHCAREA SECTIONS & DETAILS	DWG		A08-10-77 / 06-21-77	ISSUED / ISSUED	02-02-78	CONSTR	ARCH	ISSUED	OSBORNE
840-133	3	NHCAREA SECTIONS & DETAILS SH 2	DWG		A08-10-77 / 06-21-77	ISSUED / ISSUED	02-02-78	CONSTR	ARCH	ISSUED	OSBORNE
840-134	3	NHCAREA STAIR PLANS & SECTIONS	DWG		A08-10-77 / 06-21-77	ISSUED / ISSUED	02-02-78	CONSTR	ARCH	ISSUED	OSBORNE
840-135	3	NHCAREA STAIR DETAILS	DWG		A08-10-77 / 06-21-77	ISSUED / ISSUED	02-02-78	CONSTR	ARCH	ISSUED	OSBORNE
850-101	5	UTILITY FLOOR PLAN & ROOF PLAN	DWG		A07-20-77 / 06-08-77	ISSUED / ISSUED	03-17-78	CONSTR	ARCH	ISSUED	OSBORNE
850-131	4	UTILITY AREA ELEVATIONS	DWG		A07-20-77 / 06-08-77	ISSUED / ISSUED	03-17-78	CONSTR	ARCH	ISSUED	OSBORNE
850-132	3	UTILITY SECTIONS & DETAILS	DWG		A07-20-77 / 06-08-77	ISSUED / ISSUED	03-17-78	CONSTR	ARCH	ISSUED	OSBORNE

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C800-221	SEWER	CALC				08-01-77	DONE	CIVIL	DONE	PARIKH
C800-271	ROADS & PAVING	CALC				08-01-77	DONE	CIVIL	DONE	PARIKH
C800-281	GRADING	CALC				08-01-77	DONE	CIVIL	DONE	PARIKH
C811-241	TKFARM FDNS	CALC				07-14-77	DONE	CIVIL	DONE	PARIKH
C812-601	DRUMSTG FDN & GRADE SLAB	CALC				09-01-77	DONE	CIVIL	DONE	PARIKH
C815-601	CHANGEHS FOUNDATION	CALC				08-23-77	DONE	CIVIL	DONE	PARIKH
C816-501	SERVRACK PIPE RACK STEEL	CALC				07-06-77	DONE	CIVIL	DONE	PARIKH
C816-901	SERVRACK PIPE RACK FDN	CALC				07-06-77	DONE	CIVIL	DONE	PARIKH
C830-301	BIOAREA ROOF FRAMING	CALC				03-21-77	DONE	CIVIL	DONE	PARIKH
C830-302	NHCAREA ROOF FRAMING	CALC				03-17-77	DONE	CIVIL	DONE	PARIKH
C830-401	BIOAREA MISC STEEL	CALC				03-21-77	DONE	CIVIL	DONE	PARIKH
C830-402	BIOAREA SUPERSTRUCTURE	CALC				03-21-77	DONE	CIVIL	DONE	PARIKH
C830-601	BIOAREA SUPERSTRUCTURE FDN	CALC				06-30-77	DONE	CIVIL	DONE	PARIKH
C830-701	BIOAREA GRADE & SLAB FDN	CALC				07-14-77	DONE	CIVIL	DONE	PARIKH
C830-801	BIOAREA ROOF SLAB	CALC				06-01-77	DONE	CIVIL	DONE	PARIKH
C840-301	NHCAREA SUPERSTRUCTURE	CALC				03-21-77	DONE	CIVIL	DONE	PARIKH
C840-401	NHCAREA PLATFORM STEEL	CALC				03-21-77	DONE	CIVIL	DONE	PARIKH

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C840-601		NHCAREA SUPERSTRUCTURE FDN	CALC				07-14-77	DONE	CIVIL	DONE	PARIKH
C840-701		NHCAREA GRADE SLAB & FDN	CALC				07-14-77	DONE	CIVIL	DONE	PARIKH
C850-601		UTILITY SUPERSTRUCTURE FDN	CALC				07-14-77	DONE	CIVIL	DONE	PARIKH
C850-701		UTILITY GRADE SLAB & FDN	CALC				07-14-77	DONE	CIVIL	DONE	PARIKH
C851-601		COOLTWR DESIGN FDN	CALC				07-07-77	DONE	CIVIL	DONE	PARIKH
C860-601		INCINR SUPERSTRUCTURE FDNS	CALC				04-21-78	DONE	CIVIL	DONE	PARIKH
C860-701		INCINR EQUIP FDN & SLAB	CALC				04-21-78	DONE	CIVIL	DONE	PARIKH
800-103		HVAC DUCT & UNIT CURBS	DWG			ISSUED ISSUED	09-06-78	CONSTR	CIVIL	ISSUED	OSBORNE
800-215	2	FENCE - PLAN & SECTIONS	DWG		A08-31-77 10-26-77	ISSUED ISSUED	09-14-78	CONSTR	CIVIL	ISSUED	OSBORNE
800-225	6	UNDERGROUND PIPING-PLAN	DWG		A10-13-77 04-17-78	ISSUED ISSUED	07-25-78	CONSTR	CIVIL	ISSUED	OSBORNE
800-227	0	PLAN 8"SNTRY SWR,3"QNCH WTR&MNHL	DWG		A10-13-77 10-25-77	ISSUED ISSUED	10-25-77	CONSTR	CIVIL	ISSUED	OSBORNE
800-228	2	SNTRY SWR PLANS, SECTS&DTLS	DWG		A10-13-77 10-25-77	ISSUED ISSUED	07-21-78	CONSTR	CIVIL	ISSUED	OSBORNE
800-230	2	B2&NG LINE TO EXIST PLNT-KEY PLN	DWG		A11-09-77 12-16-77	ISSUED ISSUED	04-12-78	CONSTR	CIVIL	ISSUED	OSBORNE
800-231	3	B2&NG LINE TO EXIST PLANT-SECT	DWG		A11-09-77 12-16-77	ISSUED ISSUED	04-12-78	CONSTR	CIVIL	ISSUED	OSBORNE
800-232	0	B2&NG LINE-STEEL PLAN SHT #1	DWG		A11-09-77 12-16-77	ISSUED ISSUED	01-12-78	CONSTR	CIVIL	ISSUED	OSBORNE
800-233	3	B2&NG LINE-STEEL PLAN SHT #2	DWG		A11-09-77 12-16-77	ISSUED ISSUED	06-22-78	CONSTR	CIVIL	ISSUED	OSBORNE
800-234	1	B2&NG LINE-SECTS & DTLS	DWG		A11-09-77 12-16-77	ISSUED ISSUED	06-22-78	CONSTR	CIVIL	ISSUED	OSBORNE

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800-274	4	ROADS & PAVING PLAN	DWG		A08-31-77 10-26-77	ISSUED ISSUED	10-02-78	CONSTR	CIVIL	ISSUED	OSBORNE
800-275	2	ROADS & PAVING SECTIONS	DWG		A08-31-77 10-26-77	ISSUED ISSUED	09-14-78	CONSTR	CIVIL	ISSUED	OSBORNE
800-276	1	ACCESS RD/MAIN HGHWY SECT	DWG		A08-31-77 10-26-77	ISSUED ISSUED	10-26-77	CONSTR	CIVIL	ISSUED	OSBORNE
800-277	2	ACCESS RD/MAIN HGHWY DTLS	DWG		A08-31-77 10-26-77	ISSUED ISSUED	10-26-77	CONSTR	CIVIL	ISSUED	OSBORNE
800-278	2	ACCESS RD/MAIN HGHWY DTLS&PROFLS	DWG		A08-31-77 10-26-77	ISSUED ISSUED	10-26-77	CONSTR	CIVIL	ISSUED	OSBORNE
800-284	6	ROUGH GRADING PLAN	DWG		A08-31-77 08-15-77	ISSUED ISSUED	09-14-78	CONSTR	CIVIL	ISSUED	OSBORNE
800-285	1	ROUGH GRAD PLAN-ACCESS RD	DWG		A08-31-77 08-15-77	ISSUED ISSUED	10-26-77	CONSTR	CIVIL	ISSUED	OSBORNE
800-286	2	ROUGH GRADING SECTIONS	DWG		A08-31-77 08-15-77	ISSUED ISSUED	04-07-78	CONSTR	CIVIL	ISSUED	OSBORNE
800-287	1	FINISH GRADING	DWG		A10-13-77 08-15-77	ISSUED ISSUED	07-21-78	CONSTR	CIVIL	ISSUED	OSBORNE
800-951	6	HANDRAIL - STAIRS - GRATING	DWG		A05-02-77	ISSUED ISSUED	06-22-78	CONSTR	CIVIL	ISSUED	OSBORNE
800-952	2	LADDERS & CAGES	DWG		A05-02-77 10-26-77	ISSUED ISSUED	10-26-77	CONSTR	CIVIL	ISSUED	OSBORNE
800-953	2	GENERAL NOTES & MISC DTLS	DWG		A05-02-77 10-26-77	ISSUED ISSUED	10-26-77	CONSTR	CIVIL	ISSUED	OSBORNE
800-954	3	CONCRETE DTLS	DWG		A05-02-77 11-09-77	ISSUED ISSUED	06-22-78	CONSTR	CIVIL	ISSUED	OSBORNE
811-243	5	TKFARM PLAN	DWG		A08-31-77 06-27-77	ISSUED ISSUED	10-12-78	CONSTR	CIVIL	ISSUED	OSBORNE
811-244	4	TKFARM SECTIONS	DWG		A08-31-77 09-08-77	ISSUED ISSUED	09-14-78	CONSTR	CIVIL	ISSUED	OSBORNE
811-401	1	TKFARM MISC STEEL	DWG		A09-23-77	ISSUED ISSUED	08-03-78	CONSTR	CIVIL	ISSUED	OSBORNE
812-602	3	DRUMSTG FOUNDATION PLAN	DWG		A01-31-78 03-24-78	ISSUED ISSUED	10-23-78	CONSTR	CIVIL	ISSUED	OSBORNE

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813-227		ELECTSS PLAN & SECT	DWG		A04-14-78	ISSUED					
	1				03-02-78	ISSUED	06-22-78	CONSTR	CIVIL	ISSUED	OSBORNE
816-501		SERVRACK PLAN	DWG		A08-09-77	ISSUED					
	6				08-02-77	ISSUED	06-22-78	CONSTR	CIVIL	ISSUED	OSBORNE
816-531		SERVRACK SECTS & DTLS #1	DWG		A08-09-77	ISSUED					
	2				08-02-77	ISSUED	10-26-77	CONSTR	CIVIL	ISSUED	OSBORNE
816-532		SERVRACK SECTS & DTLS #2	DWG		A08-09-77	ISSUED					
	5				08-02-77	ISSUED	04-13-78	CONSTR	CIVIL	ISSUED	OSBORNE
816-902		SERVRACK FDNS - PLAN	DWG		A08-09-77	ISSUED					
	5				08-16-77	ISSUED	06-22-78	CONSTR	CIVIL	ISSUED	OSBORNE
816-931		SERVRACK FDNS - SECTS & DTLS	DWG		A08-09-77	ISSUED					
	2				08-16-77	ISSUED	11-09-77	CONSTR	CIVIL	ISSUED	OSBORNE
820-301		YARD FIRE PUMP HOUSE FDN PLAN&SECTS	DWG			ISSUED					
	0				03-10-78	ISSUED	08-01-78	CONSTR	CIVIL	ISSUED	OSBORNE
830-301		BIOAREA ROOF PLAN	DWG		A09-13-77	ISSUED					
	2				04-29-77	ISSUED	07-14-78	CONSTR	CIVIL	ISSUED	OSBORNE
830-302		BIOAREA SECOND FLOOR PLAN	DWG		A09-13-77	ISSUED					
	3				06-16-77	ISSUED	07-14-78	CONSTR	CIVIL	ISSUED	OSBORNE
830-331		BIOAREA ELEVATIONS SHT #1	DWG		A09-13-77	ISSUED					
	2				04-29-77	ISSUED	07-14-78	CONSTR	CIVIL	ISSUED	OSBORNE
830-332		BIOAREA ELEVATIONS SHT #2	DWG		A09-13-77	ISSUED					
	4				04-29-77	ISSUED	07-14-78	CONSTR	CIVIL	ISSUED	OSBORNE
830-401		BIOAREA MISC PLATFORMS & WALKWAYS	DWG		A09-13-77	ISSUED					
	3				06-16-77	ISSUED	07-14-78	CONSTR	CIVIL	ISSUED	OSBORNE
830-402		BIOAREA STAIRS PLAN & SECTIONS	DWG		A09-13-77	ISSUED					
	3				06-16-77	ISSUED	07-14-78	CONSTR	CIVIL	ISSUED	OSBORNE
830-403		BIOAREA MISC PLATFORMS & WALKWAYS	DWG		A09-13-77	ISSUED					
	1				06-16-77	ISSUED	10-26-77	CONSTR	CIVIL	ISSUED	OSBORNE
830-602		BIOAREA FOUNDATION PLAN	DWG		A09-13-77	ISSUED					
	3				06-13-77	ISSUED	07-13-78	CONSTR	CIVIL	ISSUED	OSBORNE
830-631		BIOAREA FDNS SECTS & DTLS	DWG		A09-13-77	ISSUED					
	1				06-13-77	ISSUED	11-09-77	CONSTR	CIVIL	ISSUED	OSBORNE
830-701		BIOAREA GRADE SLAB & EQUIP FDNS-PLAN	DWG		A09-13-77	ISSUED					
	3				03-13-78	ISSUED	07-27-78	CONSTR	CIVIL	ISSUED	OSBORNE

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830-731		BIOAREA GRADE SLAB & SECTS & DTLS	DWG		A09-13-77	ISSUED					
	2				07-06-77	ISSUED	06-22-78	CONSTR	CIVIL	ISSUED	OSBORNE
830-801		BIOAREA ROOF SLAB	DWG		A09-13-77	ISSUED					
	7				03-24-78	ISSUED	10-10-78	CONSTR	CIVIL	ISSUED	OSBORNE
840-301		NHCAREA ROOF PLAN	DWG		A09-13-77	ISSUED					
	1				05-17-77	ISSUED	10-26-77	CONSTR	CIVIL	ISSUED	OSBORNE
840-302		NHCAREA SECOND FLOOR PLAN	DWG		A09-13-77	ISSUED					
	3				07-07-77	ISSUED	04-13-78	CONSTR	CIVIL	ISSUED	OSBORNE
840-331		NHCAREA ELEVATIONS SHT #1	DWG		A09-13-77	ISSUED					
	2				05-17-77	ISSUED	01-12-78	CONSTR	CIVIL	ISSUED	OSBORNE
840-332		NHCAREA ELEVATIONS SHT #2	DWG		A09-13-77	ISSUED					
	3				05-17-77	ISSUED	02-09-78	CONSTR	CIVIL	ISSUED	OSBORNE
840-401		NHCAREA MISC PLATFORMS & WALKWAYS	DWG		A09-13-77	ISSUED					
	2				07-07-77	ISSUED	01-12-78	CONSTR	CIVIL	ISSUED	OSBORNE
840-402		NHCAREA MISC PLATFORMS & WALKWAYS	DWG		A09-13-77	ISSUED					
	1				07-07-77	ISSUED	10-26-77	CONSTR	CIVIL	ISSUED	OSBORNE
840-602		NHCAREA FOUNDATION PLAN	DWG		A09-22-77	ISSUED					
	2				06-15-77	ISSUED	01-26-78	CONSTR	CIVIL	ISSUED	OSBORNE
840-631		NHCAREA FDNS - SECTS & DTLS	DWG		A09-22-77	ISSUED					
	1				06-15-77	ISSUED	11-09-77	CONSTR	CIVIL	ISSUED	OSBORNE
840-701		NHCAREA GRADE SLAB & EQUIP FDNS PLN	DWG		A09-22-77	ISSUED					
	3				05-27-77	ISSUED	07-27-78	CONSTR	CIVIL	ISSUED	OSBORNE
840-731		NHCAREA GRADE SLAB - SECTS & DTLS	DWG		A09-22-77	ISSUED					
	2				11-09-77	ISSUED	06-27-78	CONSTR	CIVIL	ISSUED	OSBORNE
840-801		NHCAREA ROOF SLAB	DWG		A09-13-77	ISSUED					
	4				05-25-77	ISSUED	06-22-78	CONSTR	CIVIL	ISSUED	OSBORNE
850-401		UTILITY MISC STEEL	DWG		A08-09-77	ISSUED					
	2				10-26-77	ISSUED	10-26-77	CONSTR	CIVIL	ISSUED	OSBORNE
850-602		UTILITY FOUNDATION PLAN	DWG			ISSUED					
	0				02-17-78	ISSUED	04-07-78	CONSTR	CIVIL	ISSUED	OSBORNE
850-701		UTILITY GRADE SLAB & EQUIP FDNS	DWG		A04-20-78	ISSUED					
	1				02-23-78	ISSUED	07-05-78	CONSTR	CIVIL	ISSUED	OSBORNE
851-601		COOLTWR FOUNDATION PLAN	DWG		A09-22-77	ISSUED					
	3				07-07-77	ISSUED	07-05-78	CONSTR	CIVIL	ISSUED	OSBORNE

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851-631		COOLTWR SECTS & DTLS	DWG		A09-22-77	ISSUED					
	2				10-26-77	ISSUED	02-16-78	CONSTR	CIVIL	ISSUED	OSBORNE
860-601		INCINR FOUNDATION PLAN	DWG			ISSUED					
	2				04-14-78	ISSUED	09-25-78	CONSTR	CIVIL	ISSUED	OSBORNE
860-631		INCINR FDNS SECTS & DTLS SHT #1	DWG			ISSUED					
	1				04-14-78	ISSUED	09-25-78	CONSTR	CIVIL	ISSUED	OSBORNE
860-632		INCINR FDNS SECTS & DTLS SHT #2	DWG			ISSUED					
	1				04-14-78	ISSUED	09-28-78	CONSTR	CIVIL	ISSUED	OSBORNE

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E-1	0	ELECT BASIC SPEC	SPEC		A02-18-77 05-10-77	ISSUED ISSUED	07-20-77	CONSTR	ELECT	ISSUED	OSBORNE
E-2	1	INSTALLATION SPECS	SPEC		A07-20-77 08-03-77	ISSUED ISSUED	07-14-78	CONSTR	ELECT	ISSUED	OSBORNE
ES-14-1	3	POWER STANDARD DETAILS	SPEC		A06-24-77 06-16-77	ISSUED ISSUED	07-25-77	CONSTR	ELECT	ISSUED	OSBORNE
ES-24-1	3	LIGHTING STANDARD DETAILS	SPEC		A06-24-77 06-16-77	ISSUED ISSUED	07-25-77	CONSTR	ELECT	ISSUED	OSBORNE
ES-41-1	4	GROUNDING STANDARD DETAILS	SPEC		A06-24-77 06-16-77	ISSUED ISSUED	07-25-77	CONSTR	ELECT	ISSUED	OSBORNE
900-SKE001		LOAD STUDY	SKETCH				02-14-77	DONE	ELECT	DONE	MAKIM
900-SKE002		HEAT TRACING & POLE LINE	SKETCH				10-20-77	DONE	ELECT	DONE	MAKIM
900-101	4	GENERAL NOTES & EQUIP LIST SH 1	DWG		A06-23-77 06-16-77	ISSUED ISSUED	12-11-78	CONSTR	ELECT	ISSUED	OSBORNE
900-102	4	GENERAL NOTES & EQUIP LIST SH 2	DWG		A04-27-78	ISSUED ISSUED	12-11-78	CONSTR	ELECT	ISSUED	OSBORNE
900-103	1	480V UNIT SUB-STA SPECS SHEET	DWG		A03-15-77 06-16-77	ISSUED ISSUED	07-12-78	CONSTR	ELECT	ISSUED	OSBORNE
900-104	3	480V UNIT DATA SHEET	DWG		A03-15-77 06-16-77	ISSUED ISSUED	10-16-78	CONSTR	ELECT	ISSUED	OSBORNE
900-105	2	MCC SPEC SHEET	DWG		A03-22-77 06-16-77	ISSUED ISSUED	07-12-78	CONSTR	ELECT	ISSUED	OSBORNE
900-106	4	LIGHTING PANEL & FIXTURE SCH	DWG		A06-23-77 06-16-77	ISSUED ISSUED	10-16-78	CONSTR	ELECT	ISSUED	OSBORNE
900-107	7	LIGHTING PANEL SCHEDULES	DWG		A09-13-77 10-12-77	ISSUED ISSUED	12-28-78	CONSTR	ELECT	ISSUED	OSBORNE
900-111	3	MASTER ONE LINE DIAG	DWG		A03-29-77 11-18-77	ISSUED ISSUED	07-12-78	CONSTR	ELECT	ISSUED	OSBORNE
900-201	1	8320V DIST PLAN	DWG		A10-13-77 11-18-77	ISSUED ISSUED	10-16-78	CONSTR	ELECT	ISSUED	OSBORNE
900-203	1	8320V POLE LINE DETAILS	DWG		A10-13-77 11-18-77	ISSUED ISSUED	08-03-78	CONSTR	ELECT	ISSUED	OSBORNE

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DOCUMENT STATUS SYSTEM
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DSS STATUS REPORT *** ELECTRICAL DEPARTMENT ***

CPD-2739 CALLERY CHEMICAL COMPANY 02-16-79
NHC PLANT

DOCUMENT	REV	TITLE	TYPE	CLIENT NO	C/A	LASTREPT	SCHED COMPLETE	EXPECTED COMPLETE	IN	STATUS	RESP	OUT	BY
900-204	0	8320V POLE LINE DETAILS	DWG		A10-13-77	ISSUED	11=18-77	ISSUED	11=07=77	CONSTR	ELECT	ISSUED	HUBER
900-205	0	WELL PUMP POWER & CONTROL	DWG		D10-23-78	ISSUED	....	ISSUED	10=16=78	CONSTR	ELECT	ISSUED	OSBORNE
900-301	4	INSTRUMENT ONE LINE DIAGRAMS	DWG		A07-21-77	ISSUED	12-02-77	ISSUED	09=12=78	CONSTR	ELECT	ISSUED	OSBORNE
900-302	4	INSTRUMENT ONE LINE DIAGRAMS	DWG		A09-13-77	ISSUED	03-03-78	ISSUED	10=16=78	CONSTR	ELECT	ISSUED	OSBORNE
900-303	0	PKG UNIT CONN DIAG	DWG		D10-12-78	ISSUED	08-03-77	ISSUED	10=16=78	CONSTR	ELECT	ISSUED	OSBORNE
900-304	3	B10AREA RELAY PANEL CONN DIAG	DWG		A07-21-77	ISSUED	09-01-77	ISSUED	09=12=78	CONSTR	ELECT	ISSUED	OSBORNE
900-305	2	B10AREA INTERCONNECTION DIAG	DWG		A07-21-77	ISSUED	01=13-78	ISSUED	09=12=78	CONSTR	ELECT	ISSUED	OSBORNE
900-306	0	HEAT TRACING DETAIL SHEET	DWG		D10-17-78	ISSUED	....	ISSUED	10=16=78	CONSTR	ELECT	ISSUED	OSBORNE
900-307	1	HEAT TRACING DATA SHEET	DWG		D10-17-78	ISSUED	....	ISSUED	12=11=78	CONSTR	ELECT	ISSUED	OSBORNE
900-308	0	HEAT TRACING DETAIL SH	DWG		D12-26-78	ISSUED		ISSUED	12=11=78	CONSTR	ELECT	ISSUED	OSBORNE
910-201	5	YARD PWR LTG & GRD PLAN	DWG		A07-21-77	ISSUED	11-18-77	ISSUED	10=16=78	CONSTR	ELECT	ISSUED	OSBORNE
911-201	3	TKFARM POWER CONTL LTG GRD PLANS	DWG		A07-21-77	ISSUED	....	ISSUED	09=12=78	CONSTR	ELECT	ISSUED	OSBORNE
912-201	3	DRUMSTG PWR,CONT,LTG&GRD	DWG		A08-23-77	ISSUED	....	ISSUED	09-12=78	CONSTR	ELECT	ISSUED	OSBORNE
913-201	2	ELECTSS SUBSTATION LAYOUT	DWG		A09-13-77	ISSUED	06-27-77	ISSUED	04-04=78	CONSTR	ELECT	ISSUED	OSBORNE
915-201	3	CHANGEHS PWR,CONTL,LTG&GRD PLANS	DWG		A09-28-77	ISSUED	01-13-78	ISSUED	09-12-78	CONSTR	ELECT	ISSUED	OSBORNE
920-201	3	YARD FIRE PMP HS PWR,CNTL,LTG&GRD PLN	DWG		A04-27-78	ISSUED	01-13-78	ISSUED	10-16-78	CONSTR	ELECT	ISSUED	OSBORNE
930-111	4	B10AREA MCC SINGLE LINE DIAGRAM	DWG		A03-15-77	ISSUED	01-13-78	ISSUED	10-16-78	CONSTR	ELECT	ISSUED	OSBORNE

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CPD-2739 CALLERY CHEMICAL COMPANY
NHC PLANT

DOCUMENT	REV	TITLE	TYPE	CLIENT NO	C/A SCHED COMPLETE	LASTREPT EXPECTED COMPLETE	REMARK IN	STATUS	RESP	OUT	BY
930-112	4	BIOAREA MCC SINGLE LINE DIAGRAM	DWG		A03-15-77 01-13-78	ISSUED ISSUED	12-11-78	CONSTR	ELECT	ISSUED	OSBORNE
930-131	5	BIOAREA MCC ARRGT & DATA SHEET	DWG		A03-22-77 06-10-77	ISSUED ISSUED	12-11-78	CONSTR	ELECT	ISSUED	OSBORNE
930-151	4	BIOAREA ELEMENTARY DIAGRAMS	DWG		A07-21-77 01-13-78	ISSUED ISSUED	12-11-78	CONSTR	ELECT	ISSUED	OSBORNE
930-152	4	BIOAREA ELEMENTARY DIAGRAMS	DWG		A09-13-77 01-13-78	ISSUED ISSUED	12-11-78	CONSTR	ELECT	ISSUED	OSBORNE
930-201	6	BIOAREA POWER & CONTROL - 1ST FL	DWG		A07-20-77 01-13-78	ISSUED ISSUED	12-11-78	CONSTR	ELECT	ISSUED	OSBORNE
930-202	3	BIOAREA POWER & CONTROL - 1ST FL	DWG		A07-20-77 01-13-78	ISSUED ISSUED	09-12-78	CONSTR	ELECT	ISSUED	OSBORNE
930-203	4	BIOAREA POWER & CONTROL - 2ND FL	DWG		A07-20-77 01-13-78	ISSUED ISSUED	12-11-78	CONSTR	ELECT	ISSUED	OSBORNE
930-204	3	BIOAREA POWER & CONTROL - 2ND FL	DWG		A07-20-77 01-13-78	ISSUED ISSUED	09-12-78	CONSTR	ELECT	ISSUED	OSBORNE
930-205	4	BIOAREA PWR,CONT,LTG&GRD-ROOF PLAN	DWG		A06-25-77 01-13-78	ISSUED ISSUED	12-11-78	CONSTR	ELECT	ISSUED	OSBORNE
930-401	4	BIOAREA LTG&GRD 1ST FL	DWG		A06-25-77 07-06-77	ISSUED ISSUED	10-16-78	CONSTR	ELECT	ISSUED	OSBORNE
930-402	5	BIOAREA LTG&GRD 1ST FL	DWG		A06-25-77 11-18-77	ISSUED ISSUED	12-11-78	CONSTR	ELECT	ISSUED	OSBORNE
930-403	4	BIOAREA LTG&GRD 2ND FL	DWG		A06-25-77 07-06-77	ISSUED ISSUED	10-16-78	CONSTR	ELECT	ISSUED	OSBORNE
930-404	3	BIOAREA LTG&GRD 2ND FL	DWG		A06-25-77 01-13-78	ISSUED ISSUED	09-12-78	CONSTR	ELECT	ISSUED	OSBORNE
940-111	4	NHCAREA MCC SINGLE LINE DIAGRAM	DWG		A03-15-77 01-13-78	ISSUED ISSUED	10-16-78	CONSTR	ELECT	ISSUED	OSBORNE
940-112	2	NHCAREA MCC SINGLE LINE DIAGRAM	DWG		A03-15-77 01-13-78	ISSUED ISSUED	07-06-78	CONSTR	ELECT	ISSUED	OSBORNE
940-131	5	NHCAREA MCC ARRGT & DATA SHEET	DWG		A03-22-77 06-30-77	ISSUED ISSUED	12-11-78	CONSTR	ELECT	ISSUED	OSBORNE
940-151	3	NHCAREA ELEMENTARY DIAGRAMS	DWG		A07-21-77 01-13-78	ISSUED ISSUED	09-12-78	CONSTR	ELECT	ISSUED	OSBORNE

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*** ELECTRICAL DEPARTMENT ***

DOCUMENT	REV	TITLE	TYPE	CLIENT NO	C/A SCHED COMPLETE	LASTREPT EXPECTED COMPLETE	REMARK IN	STATUS	RESP	OUT	BY
940-152	3	NHCAREA ELEMENTARY DIAGRAMS	DWG		A07-21-77 01-13-78	ISSUED ISSUED	12-11-78	CONSTR	ELECT	ISSUED	OSBORNE
940-201	3	NHCAREA POWER & CONTROL 1ST FL	DWG		A06-23-77 01-13-78	ISSUED ISSUED	09-12-78	CONSTR	ELECT	ISSUED	OSBORNE
940-202	3	NHCAREA POWER & CONTROL 2ND FL	DWG		A06-23-77 01-13-78	ISSUED ISSUED	09-12-78	CONSTR	ELECT	ISSUED	OSBORNE
940-203	3	NHCAREA ROOF-PWR.CONT LTG & GRD	DWG		A06-23-77 08-09-77	ISSUED ISSUED	12-11-78	CONSTR	ELECT	ISSUED	OSBORNE
940-401	5	NHCAREA 1ST FL LTG & GRD	DWG		A06-23-77 01-13-78	ISSUED ISSUED	12-11-78	CONSTR	ELECT	ISSUED	OSBORNE
940-402	3	NHCAREA 2ND FL LTG & GRD	DWG		A06-23-77 08-02-77	ISSUED ISSUED	09-12-78	CONSTR	ELECT	ISSUED	OSBORNE
950-111	5	UTILITY MCC SINGLE LINE DIAGRAM	DWG		A03-15-77 01-13-78	ISSUED ISSUED	12-28-78	CONSTR	ELECT	ISSUED	OSBORNE
950-112	5	UTILITY MCC SINGLE LINE DIAGRAM	DWG		A03-15-77 01-13-78	ISSUED ISSUED	12-11-78	CONSTR	ELECT	ISSUED	OSBORNE
950-131	6	UTILITY MCC ARRGT & DATA SHEET	DWG		A03-22-77 05-19-77	ISSUED ISSUED	12-11-78	CONSTR	ELECT	ISSUED	OSBORNE
950-151	3	UTILITY ELEMENTARY DIAGRAMS	DWG		A09-28-77 01-13-78	ISSUED ISSUED	10-16-78	CONSTR	ELECT	ISSUED	OSBORNE
950-152	3	UTILITY ELEMENTARY DIAGRAMS	DWG		A09-28-77 01-13-78	ISSUED ISSUED	12-28-78	CONSTR	ELECT	ISSUED	OSBORNE
950-153	0	UTILITY ELEMENTARY DIAGRAMS	DWG		D01-11-79	ISSUED ISSUED	12-28-78	CONSTR	ELECT	ISSUED	OSBORNE
950-201	5	UTILITY POWER & CONTROL	DWG		A09-13-77 01-13-78	ISSUED ISSUED	12-28-78	CONSTR	ELECT	ISSUED	OSBORNE
950-401	6	UTILITY LTG & GRD PLAN	DWG		A06-23-77 11-18-77	ISSUED ISSUED	12-28-78	CONSTR	ELECT	ISSUED	OSBORNE
960-201	1	INCINR POWER & CONTROL	DWG		A05-26-78 04-01-78	ISSUED ISSUED	10-16-78	CONSTR	ELECT	ISSUED	OSBORNE
960-401	2	INCINR LTG & GRD PLANS	DWG		A05-26-78 04-01-78	ISSUED ISSUED	12-11-78	CONSTR	ELECT	ISSUED	OSBORNE
960-601	0	INCINR INSTRUMENTS PLAN	DWG		D10-12-78	ISSUED ISSUED	10-16-78	CONSTR	ELECT	ISSUED	OSBORNE

DOCUMENT STATUS TABULATION
CPD-2739 CALLERY CHEMICAL COMPANY
NHC PLANT

02-16-79

DEPARTMENT	LIST	PREP	CHK	APRV	ISSUE	CONSTR	DONE	HOLD	OTHERS	ROW TOTAL
PROCESS	0	0	0	0	0	26	0	0	0	26
LAYOUTS	0	0	0	0	0	24	0	0	0	24
PIPING	0	0	0	0	0	51	0	0	1	52
MATL TAKE-OFF	0	0	0	0	0	6	0	0	0	6
ISOS	0	0	0	0	0	2	0	0	0	2
MODEL MAKERS	0	0	0	0	0	0	4	0	0	4
CIVIL	0	0	0	0	0	65	24	0	0	89
ARCHITECTURAL	0	0	0	0	0	78	0	0	0	78
ELECTRICAL	0	0	0	0	0	66	2	0	0	68
INSTRUMENTS	0	0	0	0	0	44	6	0	0	50
HVAC	0	0	0	0	0	24	10	0	0	34
MECHANICAL	0	0	0	0	0	1	0	0	0	1
COL. TOTAL	0	0	0	0	0	387	46	0	1	434
PCT. TOTAL	0	0	0	0	0	89	11	0	0	100
LAST REPORT 02-02-79	0	0	0	1	0	386	46	0	1	434

APPENDIX C

ILLUSTRATIVE OPERATING

PROCEDURES

Illustrative Operating Procedures

As an example of the various procedures to be followed, the Pentane distillation system E.F.D. 114-203) is traced from initial equipment setting to normal production operation.

I. Equipment Setting:

Dravo installs all pumps and vessels according to Dravo procedures and approved specifications.

II. Piping and Electrical Installation:

Dravo or their subcontractor installs all piping and electrical materials according to Dravo procedures and approved specifications. As Dravo seals up vessels, a visual inspection is made of the inside of the vessel to check for any debris or trash that could not be removed by a solvent cleanout.

III. Pressure Testing:

Process equipment is pressure tested by the fabricator, who forwards a certified statement of pressure capability with the equipment information and prints. Piping is tested hydrostatically in sections by Dravo, according to the ASTM procedures and the design pressure rating of the pipe section. Callery must designate a code examiner who is responsible for insuring that all piping is pressure tested, and that all results are recorded in permanent form.

IV. Electrical Check-out:

Dravo's electrical subcontractor checks electrical runs for continuity and proper grounding, voltage, and overload protection. Rotating equipment is checked for proper rotation and proper functioning of switches and indicator lights. Pumps are a special case, since pressure testing of piping causes slight line movement. After pressure tests, pumps are given a final alignment to compensate for any movement. The pump motors are

checked for proper rotation with the pump uncoupled. At this point, Callery inspects the installation for acceptance.

V. Instrument Installation and Checkout:

Dravo inspects and installs all instrumentation and the associated regulators, needle valves, tubing, purge units, etc. Instrument checkout of the pentane distillation system is broken down as follows:

1. Dravo checks out control loops, remote instrumentation, and alarm circuits. The instruments tested by Dravo are TIC-5, FIC-27, the steam flow control valve, TSH and TAH-27, and TR-1. The hot water system control loop is checked by supplying regulated instrument air to TIC-5 and and FIC-27, and adjusting the set points to maximum. The control valve should open to full travel. The high temperature alarm circuit is checked by applying a heat source to TSH-27, causing TAH-27 to sound. The control room "Acknowledge" switch should stop the alarm. The temperature recorder TR-1 is checked for signal line continuity using a low-voltage source. Thermocouples are not used. Dravo does not calibrate any instrumentation.
2. Callery checks out local instrumentation such as temperature indicators, Rotameters, pressure gauges, and level gauges. The level gauge is calibrated on the pentane receiver by filling the receiver with a known liquid volume to the bottom of the level gauge. A straight-side volume calculation is then used to calibrate to the top of the gauge. The level gauge LG-141 needs no calibration. The pop valves PSV-19, 20, 22, and 23 are pre-set by the manufacturer; these are bench-tested using compressed air to check

for proper relief action at the set pressure. After the testing and installation, the only check is to be sure that the bonnet plugs are removed. The frangible disc PSE-21 needs no inspection, nor does the pentane condenser flow glass. Thermometers TI-104 and 105 are the dial type and are checked by immersion in hot water, before installation. ΔP gauge PI-105 has a range of 0-15" H_2O and is calibrated at the factory; therefore, only the zero adjustment needs checking (the movement can be checked by mouth). The series of PCV's are all adjusted by turning the set screw a certain number of turns from zero to obtain a desired pressure. This setting is made with the valves installed. The flowmeters FE-5, 6, and 41 consist of an orifice plate and ΔP gauge with a square-root flowrate scale. Each orifice must have a sharp-edged hole with no warping or damage to the plate evident. The gauge is factory-calibrated, so only the zero point should be adjusted. After these flowmeters are installed, the signal lines and valved manifold are inspected for proper orientation.

VI. Checkout of Rotating Equipment:

Upon acceptance of installation for a particular piece of rotating equipment, Callery begins its portion of the checkout. All rotating equipment is initially locked out from the electrical source. The pentane distillation system has no requirement for seal oil circulation, so the seal oil unit need not be available. All three pumps are first coupled to the drive motors. Then the bearing housings are filled with the proper amount and grade of lubricating oil, and the constant-level oilers are filled. The drive shafts are turned by hand to insure free

rotation, and then the motor control center for each pump is unlocked and energized. Eash pump is started briefly and is checked for vibration, proper rotation, and any rotational interference. If the pump performs satisfactorily, the motor control center is de-energized and locked out until the cleanout operations begin.

VII. Cleanout Procedures:

Since Dravo hydrostatically tests piping, much of the water-soluble debris should already be rinsed out at this point. The object of the cleanout is threefold: it minimizes the remaining contamination inside the process, it allows safe identification of any leak sources, and it provides a "hands-on" training step for new plant operators.

Prior to cleanout using flammable liquids, air must be purged from the equipment by displacing it with plant nitrogen. PCV-18 and 19 are set at 12" W.C., and the backpressure valve PCV-20 is set at its normal 6" W.C. N_2 is allowed to flow into the NHC purification kettle (35227) and the pentane receiver (35239) for a maximum of five minutes, at which time a sufficiently inert atmosphere is present to eliminate flammability hazards. After purging, PCV-18 and 19 are reset at the normal 6" W.C.

The cleanout of the pentane distillation system is done using pentane as the solvent. Before the cleanout is started, the plant nitrogen system must be operating. In addition, the instrument air, vent header/incinerator, cooling and process water, and steam systems are needed. Pentane is introduced into the distillation system by forwarding it from the NHC wash tank via the secondary wash pump. The procedure is as follows: ($\sim$200 gal. pentane wash)

1) Unlock motor control centers for all three pumps, and also the secondary wash pump.

2) Close the drain valve on the NHC purif. kettle (35227)
3) Open the system vent valve to the NHC vent header (valve by PCV-20)
4) Close the pentane condensate loop drain valve, and open the FE-5 throttling valve wide open. Open the pentane receiver inlet valve and vent valve.
5) Open the chilled cooling water return and supply valves to the recovered pentane condenser.
6) Check PI-105 for proper differential pressure; should indicate 6" W.C.
7) Open the drain valve on the NHC wash tank (36208) to the secondary wash pump. Open the pump discharge valve and turn on the pump to transfer the pentane to the NHC purification kettle.
8) When the transfer is complete, turn off the pump and close the drain and pump discharge valves.
9) Open the drain valve on the NHC purification kettle, and valve the NHC vac. dist. unit (47210-1) and the residue pump discharge so that the pentane may be transferred to the process drain tank.
10) Turn on the NHC purification pump and transfer the pentane batch to the process drain tank. When the transfer is complete, turn off the pump and close all valves.

A second pentane batch is run through the system for use in calibrating tank levels and dynamic testing. The first pentane batch cleans the equipment and fills up the piping, so that the second batch, which is carefully quantified, can be used as a known quantity. The batch log sheets are used for this second batch. A sample log sheet is attached at the end of these instructions. The procedure for the second batch

is as follows:

11) Repeat steps (1) to (8).

12) Open the lower jacket inlet valve on the NHC purif. kettle, then open the valve on the hot water surge pot and fill the hot water system using a service water hose. When the system appears full, turn on the pump and circulate the water. Continue filling the system until the surge pot water level is slightly above the bottom of the level gauge. Leave the surge pot fill valve open.

13) Open the steam supply valve.

14) Set PIC-27 to 75% of full scale, then set TIC-5 to 100^{o}F. Check PIC-27 to be sure steam is flowing.

15) Watch TI-104 as it approaches the pentane boiling point ($\sim$97^{o}F). Occasionally check FE-41, which should read about 20 GPM.

16) When the Pentane begins boiling, check the condenser flow glass for condensate flow. As the flow stabilizes, FE-5 should read about 1 GPM. FE-6 should read zero.

17) After ½ hour of pentane reflux, completely close the FE-5 throttling valve. FE-6 should now read about 1 GPM.

18) Boil off all the pentane in the kettle. When the kettle is dry, set PIC-27 to zero and set TIC-5 to 50^{o}F. Turn off the NHC hot water pump. Open the loop drain valve (after FE-6) to drain accumulated pentane into the pentane receiver. Leave the condenser water on.

19) Using the known volume of pentane charged to the system, mark the pentane receiver level gauge at the indicated level with the quantity contained. A straight side calculation (volume of a cylinder) is now used to completely calibrate the gauge.

20) Close the pentane loop drain valve.
21) Connect a hose and valve to the blinded tee in the pentane recycle line.
22) Position a portable drum scale near the hose and tare an empty 55-gallon drum. Leave drum on scale and set drum scale weights to tare weight plus 250 lbs.
23) Place hose in drum to near bottom of drum and ground hose to drum. Connect another hose from drum vent to inlet of high velocity vent header and open HV vent valve.
24) Open the pentane receiver drain valve, open the C_5 transfer pump (41235) discharge valve and turn on the pump. When 250 lbs of pentane have been transferred to the drum or when pentane receiver is empty, shut off pump and close discharge valve. If more than one drum is required to collect the pentane, repeat steps 22, 23 and 24.
25) When the pentane receiver is empty, turn off the pump and close both valves. Disconnect the hose and valve, and replace the blind tee.

This second cleanout batch also serves as the dynamic testing step. Dynamic testing of the pentane distillation system consists of measuring heating rates for the still pot, pumpout times for the still pot and the pentane receiver, and the overall batch cycle time. If the second cleanout batch does not provide sufficient information, another pentane batch will be processed according to the start-up procedure.

VIII. Start-up Procedures:

Since the pentane distillation is a batch operation, there is little difference between the start-up and operating procedures. However, the main emphasis during start-up is to obtain a workable and consistent operation,

while the primary concern of normal operation is to meet the production schedule. The start-up procedure and the preliminary operating procedure are as follows:

1) Close the drain valve on the NHC purification kettle (35227), and open the system vent valve (to the NHC vent header).
2) Close the pentane condensate loop drain valve, and open the FI-5 throttling valve wide open. Open the pentane receiver (35239) inlet and vent valves. Be sure the drain valve is closed, and be sure the kettle and receiver N_2 is on.
3) Open the chilled cooling water return and supply valves, to the recovered pentane condenser (31207).
4) Check PI-105 for proper differential pressure (6" W.C.), then open the drain valve on the NHC wash tank (36208) to the secondary wash pump. Open the pump discharge valve, turn on the pump, and transfer the NHC/pentane batch to the NHC purif. kettle. When finished, turn off the pump and close the drain and pump discharge valves.
5) Check the kettle jacket water supply at the surge pot level gauge LG-141. The pot should be about 1/3 full; if not, add water from a service water hose. Turn on the hot water pump after checking that the bottom jacket valve is open. (Leave the surge pot fill valve open.)
6) Open the steam supply valve. Set PIC-27 to 75% of full scale, then set TIC-5 to 100^{o}F. Check PIC-27 to be sure steam is flowing.
7) Watch TI-104 as it approaches the pentane boiling point (98^{o}F at 6" W.C.). Occasionally check FE-41, which should indicate about 20 GPM.
8) When the pentane begins boiling, condensate flow will be visible in the condenser flow glass. When flow is steady, throttle back FI-5 until the flow is ½ the flow through FI-6. (FI-5 at

approx. 0.3 GPM, FI-6 at approx. 0.6 GPM). Note on the log sheet when boiling begins.

9) Continue the stripping. If recovered pentane reaches the top of the receiver level gauge LG-114 before stripping is completed, transfer a portion of the pentane back to the storage tank: open the pentane receiver drain valve, open the pump discharge valve, and turn on the pump. Transfer about 75 gal.; record the actual quantity transferred on the log sheet. After the transfer, turn off the pump, and close the drain and pump discharge valves.

10) Continue the stripping until points 4,5 and 6 on TR-1 begin to fluctuate <u>and</u> condensate flow stops. Then, set PIC-27 to zero and set TIC-5 to 50^{o}F. Turn off the hot water pump. (Leave condenser cooling water on.)

11) Valve the NHC vacuum distillation unit to receive the crude NHC batch. Open the NHC purif. kettle drain valve, turn on the NHC purif. pump, and transfer the NHC batch to the vacuum still pot. After the transfer, shut off the pump and close the NHC purif. kettle drain valve. Note the transfer time on the batch log sheet.

12) Transfer the contents of the pentane receiver to the pentane storage tank, following the precedure given in (9). Transfer all of the pentane, and note the quantity transferred on the log sheet.

BATCH LOG SHEET

PENTANE DISTILLATION

DATE ____________________ NHC BATCH NO.__________________

OPERATOR ______________________________

TIME BATCH
CHARGE COMPLETED ___________ VOL. CHARGED FROM
NHC WASH TANK______________ GAL.

TIME REFLUX
STARTED __________________

	START	+1 HR.	+2 HR.	+3 HR.	+4 HR.	+5 HR.	+6 HR.
FE-5 REFLUX FLOW							
FE-6 PRODUCT FLOW							
TI-104 POT TEMP.							
PI-105 POT PRESS.							
FE-41 HOT WATER FLOW							
PIC-27 STEAM FLOW							
TI-105 RCVR. TEMP.							
LG-114 RCVR. LEVEL							

TIME DISTILLATION
COMPLETED_________________

VOL. IN PENTANE
RECEIVER _____________________ GAL.

RECEIVER TEMP.
(TI-105)______________________

APPENDIX D

MAINTENANCE PROCEDURES

MAINTENANCE PROCEDURES

Each major piece of equipment (those with item numbers) has its own maintenance file, listed by item number. This file includes:

a) Maintenance Record Sheet with Prevent. Maint. Schedule
b) Removal-From-Service Procedure
c) Maintenance and Repair Instructions
d) Equipment Drawings and Dimensions
e) Parts and Materials List
f) Performance Charts/Tables
g) Recommended Spare Parts List
h) Operating Manual(s)

The Maintenance Record Sheet contains a listing of all maintenance work performed on a particular equipment item. This sheet also contains the item's preventive maintenance schedule, and a running balance of spare parts in stock. The Preventive Maintenance Schedule is posted on a master calendar which shows all of the scheduled plant maintenance activity for a year's time. The information from the Maintenance Work Order forms is used to update the record sheet. Spare parts are stored in shelf bins and are identified by equipment item number and part number. When a part from stock is used, it will be noted on the Maintenance Work Order; before the work order is filed a replacement spare part will be ordered via a Requisition Form. A copy of this Requisition is also kept in the Maintenance file.

The Removal-From-Service Procedure details the steps necessary for safely isolating the equipment from process materials and/or power supply. When maintenance on the bench is required, this procedure is used to get the equipment from on-line operational status to the repair station.

The remainder of the Maintenance File contents is supplied by the equipment vendor. Exhibit "A" gives an example of a typical equipment maintenance file.

Process instrumentation has a separate maintenance file containing the information listed above, plus an "Initial Instrument Calibration Sheet", which gives the settings at which the instrument was first used in process service. All subsequent changes in the instrument settings will be noted on this sheet. In addition, the process variable(s) that is the basis for the settings is also recorded. A sample Initial Instrument Calibration Sheet is included at the end of Exhibit "A". All Instrument Maintenance Files are classified alphabetically according to the instrument identification number on the most recent edition of the appropriate engineering flow diagram. Spare parts are classified in the same manner.

Keeping an Instrument Maintenance File containing the above information allows identification of any instruments that are unreliable or poorly suited to the process application. In addition, when the plant production rate is increased, the Maintenance Files will allow an orderly recalibration program to be instituted.

Process equipment not having item numbers (e.g., valves) and instrument accessories not having identification numbers (e.g., air regulators) are listed by name in alphabetical order in the Maintenance Files.

MINE SAFETY APPLIANCES COMPANY

MAINTENANCE REQUEST & WORK ORDER

TO: MAINTENANCE DEPT. [X] REQUEST DATE 7/25 JOB NO. M

(CHARGE APPROPRIATE FUNCTION A/C)

TOOL ROOM [ ] REQUEST NO. SAMPLE

CHARGE DEPT. NO. DEPT. NAME NHC

TE REQUIRED REQUESTED BY NHC OPERATOR

TYPE OF MAINTENANCE: SCHEDULED [X] PREVENTIVE [ ]

EMERGENCY [ ] MOVE & REARRANGE [ ]

UIPMENT OR TOOL NAME NHC HOT WATER PUMP

PROPERTY TAG OR TOOL NO. REQUIRING SERVICE 41248

SCRIPTION OF WORK REQUIRED LEAKING AT SEAL

REPLACED SEAL

REQUIRED: 1 DURA-SEAL, SINGLE INSIDE ROTT-TYPE

4 HOURS LABOR

	LABOR COST	MATERIAL COST	TOTAL COST
TIMATED	$	$	$
ACTUAL	$	$	$

ESTIMATED BY

ACTUAL BY

RVICE DEPT. APPROVAL DATE

ANAGEMENT APPROVAL ($200 OR MORE) DATE

DATE SCHEDULED 7/31 SCHEDULED BY

TE STARTED 7/31 DATE COMPLETED 7/31

COST ACCOUNTING COPY

MACHINE NO.	TYPE MACHINE	J	F	M	A	M	J	J	A	S	O	N	D	1	2	3	4
41248	NHC HOT WATER PUMP - CENTRIFUGAL TYPE																
MACHINE NO.	TYPE MACHINE													1	2	3	4

MAINTENANCE RECORD

MECHANICAL AND ELECTRICAL INSPECTIONS SCHEDULE

YEAR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52
19																										X																										
19				CHECK ALIGNMENT AND CLEARANCES EVERY SIX (6) MONTHS																																																		
19																																																				

OIL CHANGE AND LUBRICATION SCHEDULE

YEAR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52
19								X								X								X								X								X								X				
19													CHECK OIL LEVEL EVERY TWO (2) WEEKS																																								
19																																																				

DATE	WORK ORD.	DESCRIPTION OF REPAIRS AND REPLACEMENTS	DOWN TIME	MAN HOURS	MATERIAL COST	TOTAL COST
7/31	SAMPLE	REPLACED MECHANICAL SEAL	4 HRS.	4 HRS.		

PRINTED IN U.S.A. BY Pocahontas, WABASH, INC. PREVENTIVE MAINTENANCE RECORD C-014614 CT

WORK ORD.	DESCRIPTION OF REPAIRS AND REPLACEMENTS	DOWN TIME	MAN HOURS	MATERIAL COST	TOTAL COST

MACHINE NO 41248 TYPE MACHINE CENTRIFUGAL PUMP CAT. NO. AA SERIAL NO.

VENDOR LABOUR PUMP COMPANY DATE PURCHASED 6/78 DATE INSTALLED 11/78

PURCHASE COST INSTALLATION COST TOTAL COST DEPRECIATION YEARS PER YEAR

SPARE PARTS

DATE	PART NO.	DESCRIPTION	REC'D	USED	BAL.
/31		DURA-SEAL			
-----	----	SINGLE INSIDE ROTT		1	1

MECHANICAL EQUIPMENT

ELECTRICAL EQUIPMENT

EQUIPMENT			
MAKE			
SERIAL NO			
TYPE FRAME			
VOLTAGE			
PHASE			
AMPERES			
HORSE POWER			
R. P. M.			
DRIVE			
CIRCUIT			
DATE INST.			

REMOVAL FROM SERVICE

41248 - NHC HOT WATER PUMP

Before the pump can be removed, follow the pentane distillation operating instructions to shut down processing in this system.

1) Turn down the set point on PIC-27 to zero and set TIC-5 at 50°F.
2) Shut off the steam supply hand valve to the double heater.
3) At the pump motor control center, turn off the power and lock the switch handle in the OFF position, using an issued mechanic's safety lock.
4) Open the fill valve on the hot water surge pump.
5) Close the two jacket inlet valves on the pentane distillation kettle.
6) Remove the drain plug from the pump casing, and drain the water from the pump and line. Remove coupling.
7) When the line has been drained, remove the pump from the line flanges and the pump base.

NOTE - If the pump bearings need maintenance, it may not be necessary to remove the entire pump from service. See the Labour Maintenance Manual.

INSTRUCTIONS FOR THE INSTALLATION, CARE AND OPERATION OF LaBOUR ANSI STANDARD PUMPS

This bulletin gives information on the proper installation, operation and maintenance of LaBOUR Group S and Group L ANSI Standard pumps. The drawings and description will acquaint the operators and maintenance men with the mechanical construction of the pumps.

Immediately on arrival the pump should be carefully examined for evidence of damage while in transit and any damage should be reported to the carrier.

Before installation of the pump the shaft should be turned over by hand to determine that there is no binding or rubbing. Care must be exercised in the alignment of the pump and motor shaft. Pumps with motors mounted and accurately aligned at our factory may be mishandled in transit. Therefore, it is recommended that pump and motor shaft alignment be rechecked before installation.

INSTALLATION OF PUMP

The pump should be so located as to be readily accessible for proper attention and convenience of maintenance. The suction and discharge piping must properly match the pump flanges. To avoid excessive mechanical loading the suction and discharge piping must not be strained in making the final connection at the pump. All piping must be supported independently from the pump.

The pump should be located as close as possible to the source of supply with a minimum of elbows and fittings in the suction line which would cause turbulence and loss of head due to friction. It is suggested that no elbow or similar fitting be installed less than five pipe diameters from the suction flange.

As baseplates can be distorted when foundation bolts are tightened it is recommended that the unit be rechecked after this is done to be certain the shaft turns freely by hand. The pump and motor shaft should be checked for angular and/or parallel misalignment.

CAPACITY OF THE PUMP

Pumping capacities are ordinarily expressed in terms of volume of liquid handled per unit time; together with the total head against which the pump is to operate. The capacity of the pump is generally given in gallons per minute (GPM), and the head is expressed in feet. As long as the head is expressed in feet and not in pounds pressure, the capacity-head characteristics are the same, regardless of the specific gravity. All LaBour pumps are carefully tested with water. Pump performance will generally be the same regardless of the specific gravity of the liquid being handled. The power required to drive the unit will vary in direct proportion to the specific gravity of the liquid. Wide variations in the viscosity will change the pumping characteristics somewhat as well as the power input required.

MATERIALS OF CONSTRUCTION

LaBour pumps are furnished in wide variety of construction materials, these being especially selected for the liquids to be handled and the duty to be performed. When the pump leaves the factory it is tagged, indicating the metal used in the pump casing and also indicating the metal of which the impeller is made. Care should be taken to see that pumps constructed of given metals are applied only for handling liquids for which they are suitable.

STARTING THE PUMP

The oil was drained from the bearing housing before shipment. The bearing housing must be filled to the proper level as indicated on the housing casting. The proper oil level is established and maintained by the Gits constant level oiler (Size #3275-4A for Group S and #3275-8A for Group L pumps) supplied with each pump. The oil reservoir should be checked regularly to ensure proper oil level.

For high speeds (2900-3500 RPM) or low temperatures use a good automotive or turbine grade SAE #10 oil. For lower speeds and/or higher temperatures an SAE #20 oil is recommended.Bearing housings are provided with water jackets that can be drilled and tapped for cooling connections when specified. Do not depend upon the hand to determine operating temperatures for bearings. The actual temperature should be determined with a thermometer as it is impossible to comfortably hold the hand on the bearing housing even when the bearings are well below safe operating temperatures. When handling liquids at 300 deg. F and above, water cooling of the oil is desirable. However, if a particular installation is such that water for cooling is not feasible an oil temperature up to 180 deg. F is permissible.

If the installation has been properly made the pump is almost ready for starting. A careful check should be made to see that no foreign material has become lodged in the pump. Protective closures are provided on the suction and discharge openings when the pump leaves the factory.

CAUTION
The direction of rotation is clockwise when facing the coupling end of the pump shaft as indicated by the arrow cast on the pump casing. Incorrect rotation may cause the impeller to unscrew and jam against the casing. To prevent this possibility the spacer is not assembled to the coupling but is packaged separately with the pump. Before installing the coupling spacer, or making permanent electrical connections, the direction of rotation should be checked as well as the alignment of the pump and motor shafts for misalignment sometimes results from mishandling during transit.

STUFFING BOX

The stuffing box space provides for five rings of packing with a seal cage and repacking space. Group "S" pumps (1⅛" dia. shaft) require 5/16" square packing and Group "L" pumps (1⅞" dia. shaft) require ⅜" square packing.

The gland on pumps handling corrosive liquids must be intelligently operated and maintained for satisfactory results. It is important when repacking to use the correct size and kind of packing for the particular service. Acid handling pumps generally use Asbestos packings which are very abrasive and are apt to score the pump shaft if not properly used. The packing should be well lubricated and the gland should not be maintained excessively tight.

New packing should be cut to such length that when the ends are butted together a ring will be formed which is slightly larger in diameter than the packing chamber. When forced into place the ends will be held tightly together. Care must be taken to stagger the joints.

The lantern ring communicates with a grease or liquid passage in the stuffing box cover and if it is not properly positioned the grease or liquid cannot flow to this ring. To ensure proper positioning of the lantern ring all of the old packing must be removed and three rings of new packing installed ahead of the lantern ring and two rings behind. When installing the Teflon lantern ring, the butted ends should be twisted apart just sufficiently to clear the shaft. Do not spread the ends directly apart. The gland should be maintained as loose as possible without excessive leakage, particularly during the packing "run in" period.

The stuffing box cover is provided with two ¼" pipe tap connections for liquid sealing or quenching. CAUTION: WATER SEALING MUST NOT BE USED WITH CONCENTRATED SULPHURIC ACID. The sealing liquid must be compatible with the liquid being pumped. Liquid sealing of the gland is customary for pumps operating with vacuum on the suction to prevent an excessive amount of air being drawn past the gland.

Pumps for handling hot liquids can be furnished (on special order) with a stuffing box cover having an annular water chamber surrounding the packing. Keeping the gland temperature as low as possible is helpful in extending the packing life.

MECHANICAL SEALS

For pumps equipped with mechanical seals, refer to the seal manufacturers drawings and Instructions which are shipped with the pump.

REPAIRING THE PUMP

All rotating parts are contained in a single assembly, which may be removed or replaced as a unit without disturbing pipe connections or motor and without affecting alignment. The drawings in this booklet show the simplicity of this construction. If desired, an entire new drive unit with impeller may be quickly installed, permitting prompt resumption of service while repairs are being made.

TO DISASSEMBLE PUMPS

1. Remove coupling guard.
2. Remove Flexible Coupling spacer.
3. Remove bolts holding bearing housing foot to base.
4. Remove nuts from casing studs. The drive unit may now be pulled away from the casing as a complete assembly for repair or replacement.
5. To remove the impeller—
   (a) Hold shaft from turning (couplings normally furnished are provided with hub flats for this purpose).
   (b) When facing impeller turn blades counterclockwise to remove.
6. For pumps with packed stuffing box loosen gland stud nuts to relieve pressure on packing. For pumps with mechanical seals refer to the applicable seal drawing. Inside mounted seals require that the seal gland be removed before removing the stuffing box cover.
7. Remove the two stuffing box cover cap screws (Pc. #211). The stuffing box cover (Pc. #210) may now be removed. No further disassembly is required to repair or replace a mechanical seal.
8. To remove Shaft and Bearings, remove the four bearing cover cap screws (Pc. #234) and shaft assembly can then be withdrawn from the bearing housing.

REASSEMBLY OF PUMP

Reassembly of the pump is just the reverse of the steps for disassembly. When reassembling a pump, care must be taken that when the impeller is firmly seated in position there is a clearance of approximately .020" between the impeller blades and the stuffing box cover (Pc. #210). This will allow not less than 1/32" clearance between the front of the impeller blades and the pump casing through the use of a 1/16" thick casing gasket. The use of a thinner gasket will reduce the clearance and a thicker gasket will mean excessive clearance between the impeller and the pump casing. Because of the high co-efficient of expansion of chrome alloys, the impellers in pumps of such metals are set closer to the stuffing box cover than to the pump casing.

To replace bearings they are pressed off the shaft. The new bearings should be heated in oil or under a heat lamp to a temperature of 300 deg. F., at which temperature they can be slipped over the shaft and seated snugly against their respective shaft shoulders. The rear bearing (Pc. # 228) is drawn into place by the locknut (Pc. # 229) which is then secured by the lockwasher (Pc. # 230).

When replacing oil seals care must be used in pressing them squarely into the bearing housing adapter (Group L pumps), the bearing housing (Group S pumps) and the bearing cover. Oil the lips of the seals and use care when installing the shaft in the housing and the rear cover on the shaft to avoid damage to the lips of the oil seals.

TO SET IMPELLER CLEARANCE

Replacement of the Stuffing Box Cover (Pc. #210), Bearing Housing (Pc. #223), Adapter (Pc. #218), Shaft (Pc. #226) and/or Outboard Bearing (Pc. #228) may necessitate readjustment of the clearance (.020") between the Impeller blades and Stuffing Box Cover. Resetting of the impeller clearance should be done with the drive unit disassembled from the casing. Move shaft assembly forward until the outboard bearing snap ring without shim is snugly against the face of the bearing housing. Measure the clearance between the back of the impeller blades and the Stuffing Box Cover. Whatever this measurement exceeds .020" will be the total amount of shims to be installed between the bearing snap ring and the face of the bearing housing. Move shaft assembly back toward coupling end and remove bearing snap ring. Install proper thickness of shims and reinstall bearing snap ring being certain that it is properly seated in the groove of the bearing. Install bearing Cover Gasket (Pc. #233) then Bearing Cover (Pc. #232) which is drawn snugly into place with Bearing Cover Cap Screws (Pc. #234). If Adapter (Pc. #218) on Group L pumps is disassembled from the Bearing Housing (Pc. #223) be certain when reassembling these parts to install the Adapter Gasket (Pc. #219).

OPERATING INFORMATION

If pump requires too much power, the following possible causes should be checked:

A. Dynamic head materially lower than that specified. This will usually increase the capacity and power required.

B. Specific gravity of liquid higher than that for which the pump was powered. The power varies directly as the specific gravity.

C. Viscosity of the liquid too high.

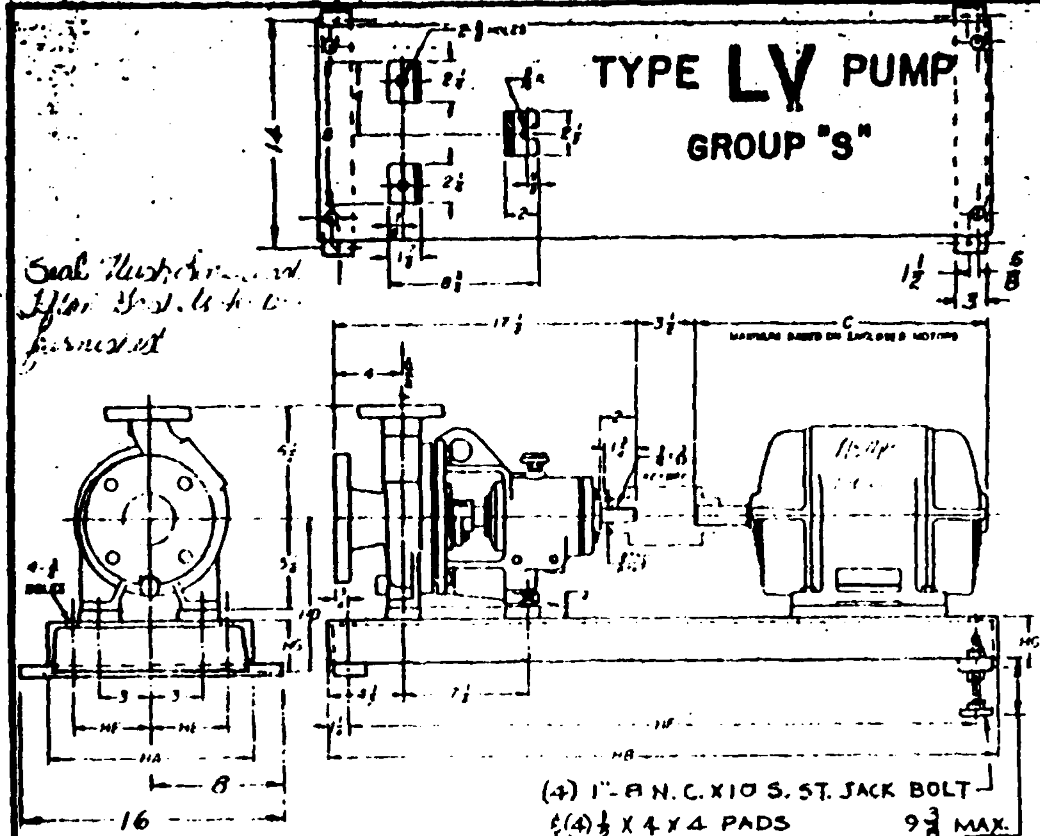
D. Mechanical damage, such as impeller rubbing.

E. Scale deposits or other obstructions inside of pump casing and in contact with rotating parts.

F. Mechanical or adjustment defects in the prime mover or power supply, resulting in a lower output and an apparatus over-load.

GIVE PIECE NUMBER AND PUMP SERIAL NUMBER WHEN ORDERING REPAIR PARTS

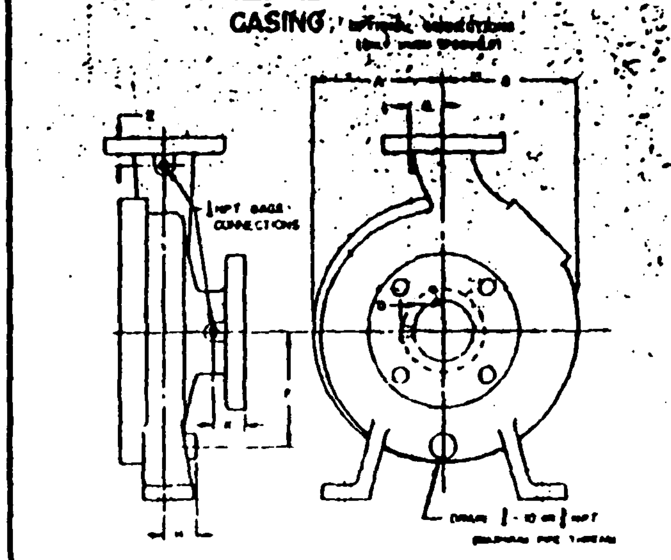
TYPE LV PUMP
GROUP "S"



Seal illustrated ... furnished

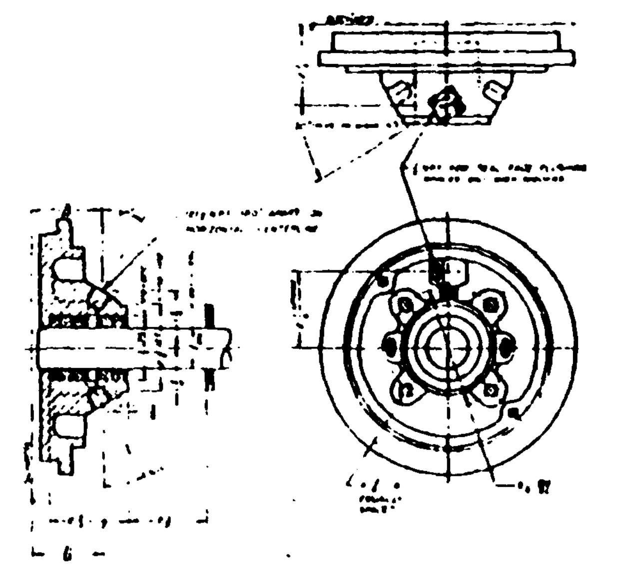
PUMP SIZE	SUCTION SIZE	DISCHARGE SIZE	MOTOR FRAME	C	BASE SIZE	HA	HB	HD	HE	HF	HG	WEIGHT PUMP	WEIGHT BASE
AA	1 1/2	1	H143T-182-182T	[illegible]	A	10	35	8 1/4	4	32 1/2	3	70	75
AB	3	1 1/2	H145T-H145T-184	[illegible]								85	
AA	1 1/2	1	[illegible]	[illegible]	B	12	39	8 1/2	4 1/2	36 1/2	3 1/4	70	90
AB	3	1 1/2	[illegible]	[illegible]								85	
AA	1 1/2	1	[illegible]	[illegible]	2S	15	52	[illegible]	6	49 1/2	3 7/16	70	170
AB	3	1 1/2	[illegible]	[illegible]								85	

CASING



PUMP SIZE	STANDARD NO.	A	B	C	D	E	F	H	K
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

STANDARD STUFFING BOX COVER



OPTIONAL FEATURES:

■ COUPLING GUARD ☐ JACKETED

■ MECH. SEAL MFG. [illegible] TYPE [illegible]

■ INSIDE ☐ OUTSIDE ■ SINGLE ☐ DOUBLE

■ COUPLING MFG. [illegible] SIZE [illegible]

☐ $\frac{3}{4}$-10 GASKETED DRAIN PLUG

■ $\frac{3}{8}$ P.T. DRAIN CONN. ☐ $\frac{1}{4}$ P.T. GAGE

CUSTOMER [illegible]

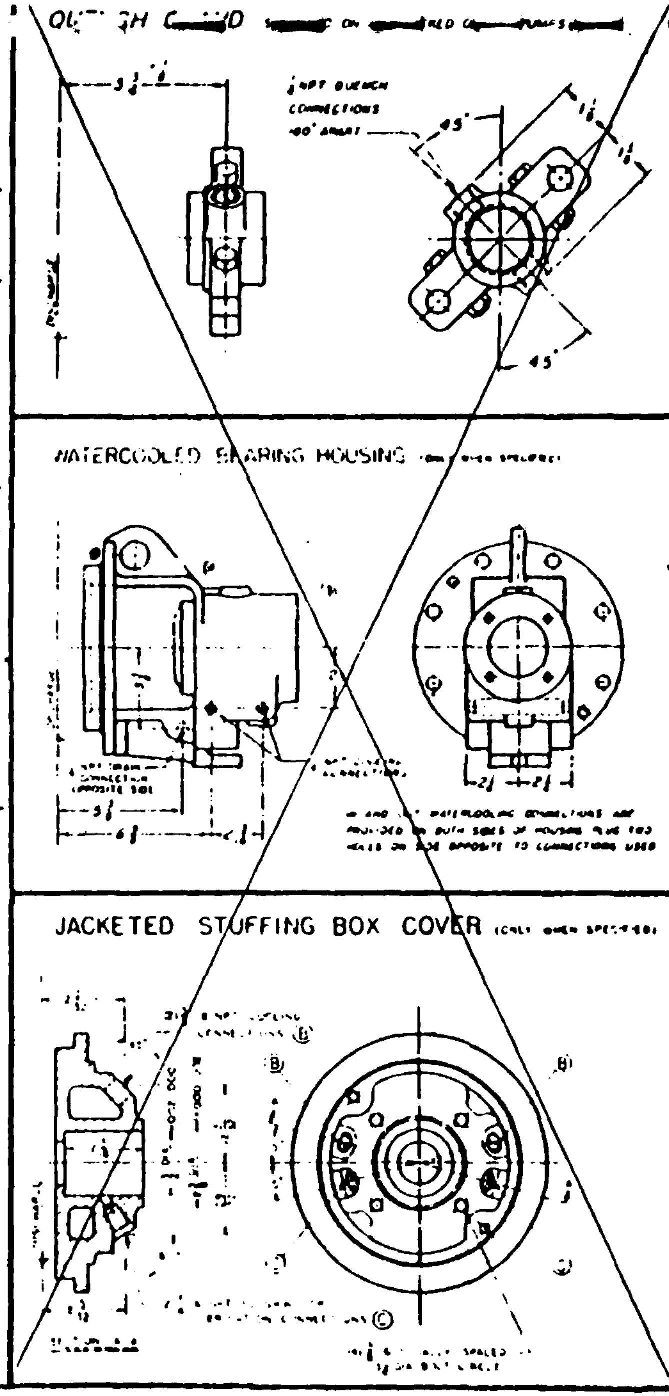
CUSTOMER ORDER NO. [illegible]

ITEM / REQN. NO. 41248

OUR ORDER NO. [illegible] PUMP SIZE [illegible] BASE NO. BAS-0-A PE 9326

CERTIFIED BY [illegible] DATE [illegible]

PUMP MARKINGS [illegible]

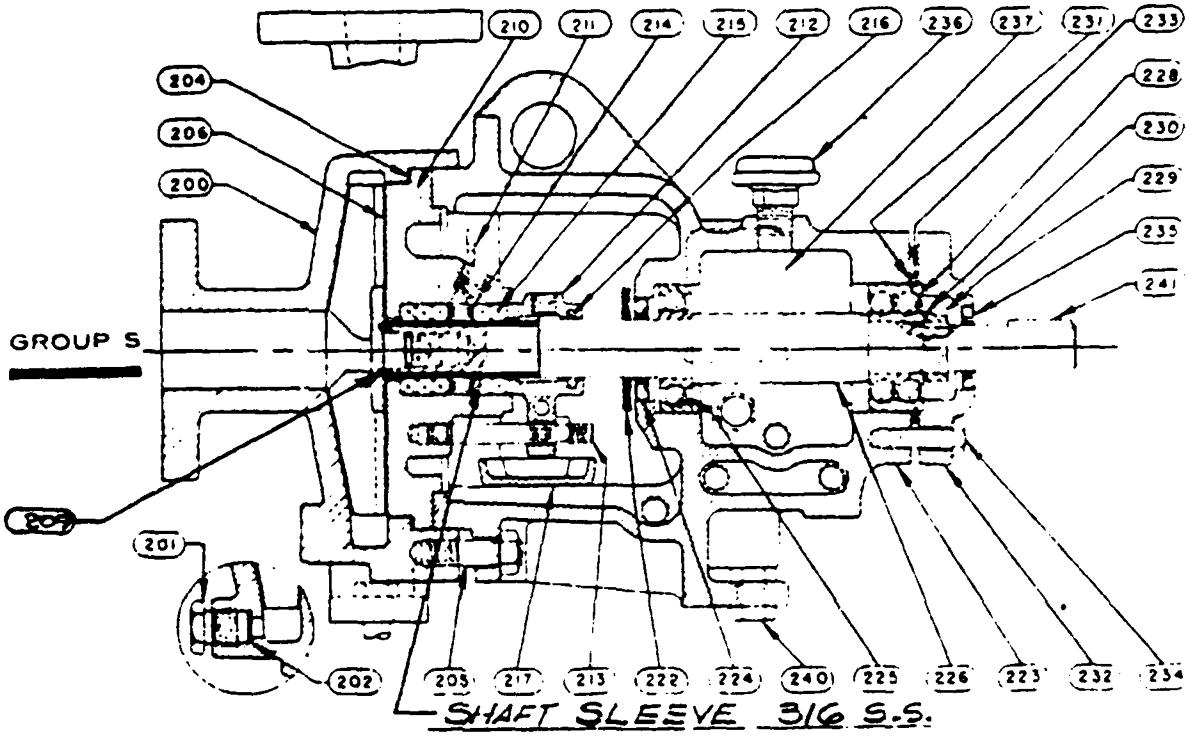


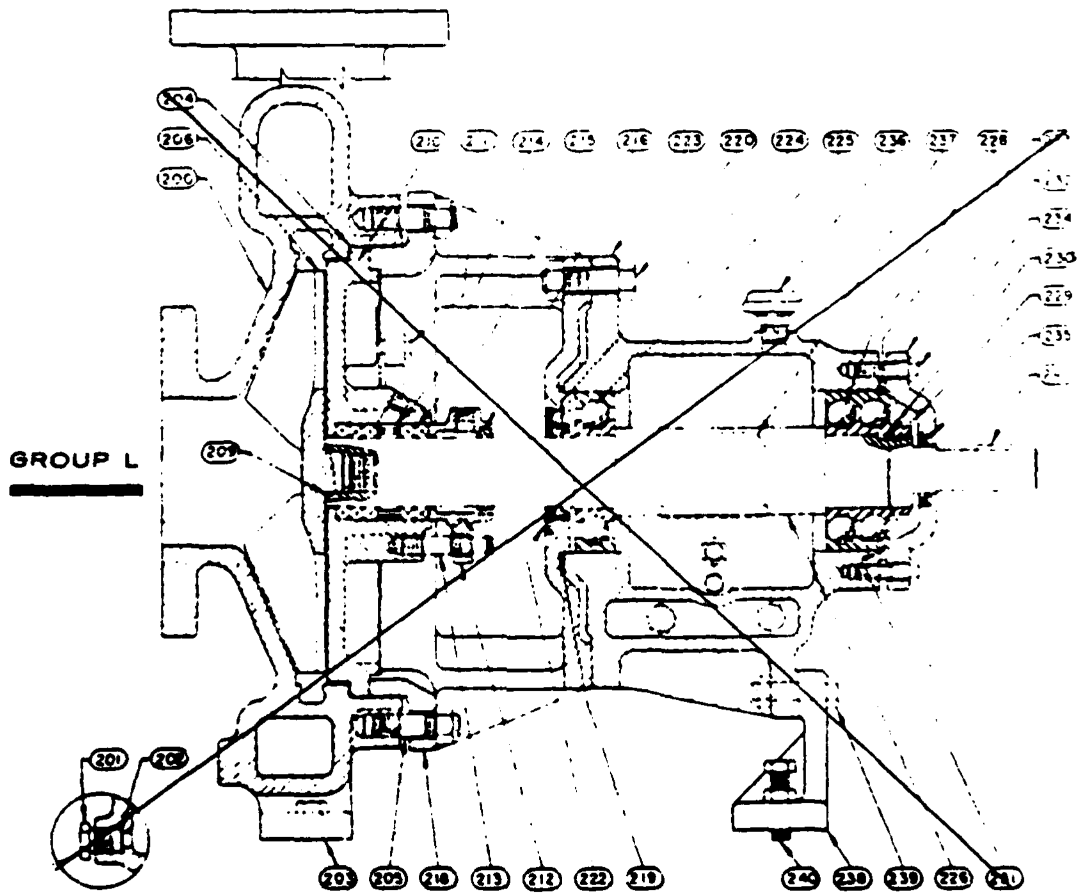
DIMENSIONS APPROVED
LABOUR PUMP CO., ELKHART INDIANA
DIVISION OF AMERICAN GAGE & MACH. CO.

4-26-73

FORM E-12581 CB
STILT BASE

LaBour ANSI Pumps





PARTS AND MATERIAL LIST

PC NO	NO REQ'D	PART NAME	WET END MATERIAL: CAST IRON			304	316	ELCOMET K	R-55		NICKEL	Y-17	Y-30
2..	1	CASING	CI	CI	CI.	304	316	K	R-55	D.I.	NICKEL	Y-17	Y-30
201	1	CASING DRAIN PLUG	CI	CI	CI	304	316	K	R-55		NICKEL	Y-17	Y-30
2..	1	IMPELLER	316	K	R-55	304	316	K	R-55	316	NICKEL	Y-17	Y-30
2..	1	STUFFING BOX COVER	CI	CI	CI	304	316	K	R-55	D.I.	NICKEL	Y-17	Y-30
226	1	SHAFT (C.A.S.)	[redacted]							CAD	[redacted]		
2..	1	GLAND	316	R-55		316		R-55		316	NICKEL	Y-17	Y-30
2..	1	DRAIN PLUG GASKET	TEFLON										
204	1	CASING GASKET	ASBESTOS										
2..	1	IMPELLER GASKET	TEFLON										
21..	1 SET	STUFFING BOX PACKING	ASBESTOS										
214	1	LANTERN RING	TEFLON										
2..	1	CASING FOOT (A-10 ONLY)	CAST IRON										
205	▲	CASING STUDS & NUTS	STEEL			STAINLESS							
2	2	STUFFING BOX COVER CAP SCREW	STAINLESS										
213	2	GLAND STUD & NUT	STAINLESS			ELCOMET-K							
216	1	GLAND PACKING	ASBESTOS										
2	1	DRIP PAN	NONE			ELCOMET-K							
218	1	ADAPTER	(GROUP L ONLY)			CAST IRON							
2..	1	ADAPTER GASKET	(GROUP L ONLY)			BUNA-N							
2	4	ADAPTER CAP SCREW	(GROUP L ONLY)			STEEL							
222	1	DEFLECTOR	NEOPRENE										
2..	1	BEARING HOUSING	CAST IRON										
2..	1	INBOARD OIL SEAL	GROUP "S" 112-200-12					GROUP "L" 187-262-12					
225	1	INBOARD BEARING	GROUP "S" P-206W FAFNIR					GROUP "L" P-310K FAFNIR					
2..	1	OUTBOARD BEARING	GROUP "S" P-5305KG FAFNIR					GROUP "L" P-5310WG FAFNIR					
2..	1	BEARING LOCKNUT	STEEL										
230	1	BEARING LOCKWASHER	STEEL										
2	1	BEARING SHIM	STEEL										
232	1	BEARING COVER	CAST IRON										
233	1	BEARING COVER GASKET	BUNA-N										
2	4	BEARING COVER CAP SCREW	STEEL										
235	1	OUTBOARD OIL SEAL	GROUP "S" 087-162-12					GROUP "L" 125-200-12					
2..	1	BEARING HOUSING BREATHER	STEEL										
237	1	CONSTANT LEVEL OILER	PLASTIC/STEEL										
2..	1	BEARING HOUSING FOOT	CAST IRON										
2..	2	CAP SCREW FOR FOOT	STEEL										
240	2	FOOT LEVELING SCREW & NUT	STEEL										
2..	1	COUPLING KEY	STEEL										

* ALSO AVAILABLE IN DUCTILE IRON, BRONZE AND ALUMINUM

○ ONLY WHEN SPECIFIED

▲ SIZES AA & AB ———— 8 REQ'D

SIZE A-10 ———— 10 REQ'D

SIZES A-20 THRU A-70 ———— 12 REQ'D.

CUSTOMER [illegible]

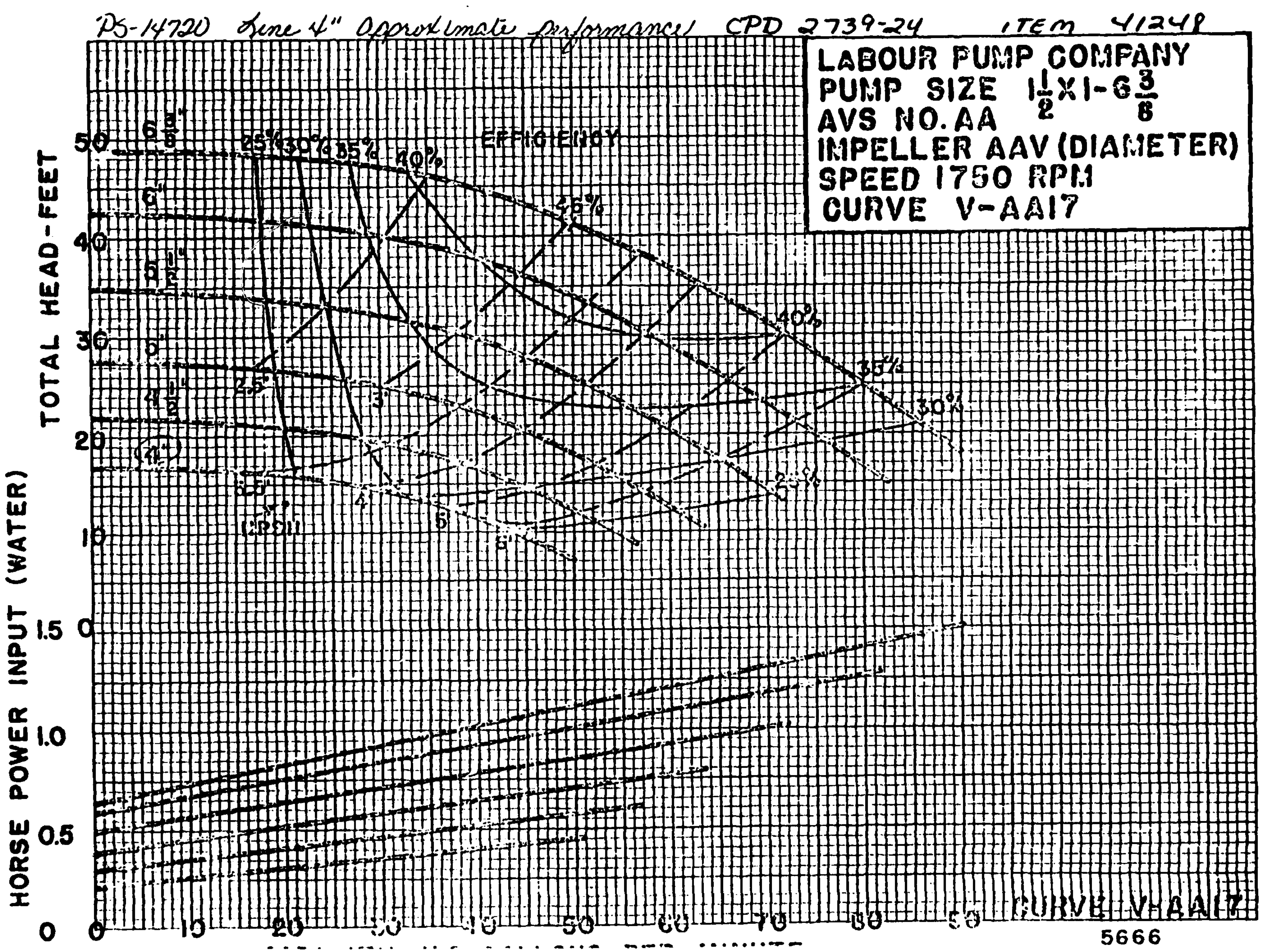
CUSTOMER ORDER NO [illegible]

ITEM / REQ'N NO 41248

LaBOUR PUMP COMPANY ELKHART, INDIANA 46514

DIVISION OF AMERICAN GAGE AND MACHINE COMPANY

FORM F-12400


PS-14720 Line 4" Approximate performance CPD 2739-24 ITEM 41248
LABOUR PUMP COMPANY
PUMP SIZE 1 1/2 X 1-6 3/8
AVS NO. AA
IMPELLER AAV (DIAMETER)
SPEED 1750 RPM
CURVE V-AA17
EFFICIENCY
25% 30% 35% 40%
6 3/8"
6"
5 1/2"
5"
4 1/2"
4"
45%
40%
35%
30%
25%
2.5'
3'
4'
5'
6'
NPSH
TOTAL HEAD-FEET
HORSE POWER INPUT (WATER)
0 10 20 30 40 50 60 70 80 90
CURVE V-AA17
5666

N 17160

RECOMMENDED SPARE PARTS FOR STOCK

E-12401-1

LaBOUR TF & LV PUMPS
(FORM E-12400)

FOR MILDLY CORROSIVE AND/OR ABRASIVE SERVICE

CPD 2739-24
ITEM 41248

Quantity	Pc.#	Part
1	206	Impeller
1	209	Impeller Gasket
1	225	Inboard Bearing
1	226	Shaft
1	228	Outboard Bearing
1	229	Bearing Locknut
1	230	Bearing Lockwasher
1	204	Casing Gasket
1	219	Adapter Gasket
1	233	Bearing Cover Gasket
1	224	Inboard Oil Seal
	235	Outboard Oil Seal

IN ADDITION SOME CUSTOMERS PREFER TO CARRY ON HAND:

FOR SAKE OF CONVENIENCE SOME CUSTOMERS MAY PREFER TO STOCK A COMPLETE BEARING HOUSING ASSEMBLY (PC. NO. 221), WHICH MAY BE REMOVED OR REPLACED AS A UNIT.

THIS ASSEMBLY CONSISTS OF:

1	222	Deflector
1	223	Bearing Housing
1 Each	224, 225, 226, 228, 229, 230, 233, 235	Listed Above
1 Set	231	Bearing Shims
1	232	Bearing Cover
4	234	Bearing Cover Cap Screws
1	236	Bearing Housing Breather
1	237	Constant Level Oiler

FOR EXTREMELY SEVERE SERVICES IT IS RECOMMENDED THAT A COMPLETE PUMP, LESS BASEPLATE AND FLEXIBLE COUPLING, BE CARRIED AS A SPARE.

LaBOUR PUMP COMPANY

Elkhart, Indiana

E-12401-1

10-25-76

INITIAL INSTRUMENT CALIBRATION SHEET

DATE ________________________________

INST. IDENTIFICATION ____________________ LOCATION ____________________________

TYPE ____________________

MANUFACTURER & MODEL ____________________

___ CONTROLLER ___ INDICATOR ___ TRANSMITTER

___ SWITCH ___ ALARM ___ RECORDER

___ OTHER ____________________

PROCESS MATERIAL
BEING MEASURED ____________________

PROCESS VARIABLE(S)
BEING MEASURED ____________________

AT ____ ^{o}F ______psig ________GPM

RANGE OF VARIABLE(S) ________________

ADJUSTMENTS MADE TO INSTRUMENT:
(specify air/N_2 supply pressure)

ADDITIONAL ADJUSTMENTS MADE TO INSTRUMENT:
(give date and reason for change)